AFRL-RX-WP-TR-2013-0054

NONMETALLIC MATERIALS SUPPORTABILITY

Task Order 0001: Nonmetallic Materials Supportability

Project [1-052]: The Evaluation of Two-Part Epoxy Paste Adhesives for Repair Bonding of Aluminum Alloys

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OCTOBER 2011
Interim Report

AIR FORCE RESEARCH LABORATORY
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UNITED STATES AIR FORCE

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
October 2011	Interim	01 April 2010 – 30 September 2011

4. TITLE AND SUBTITLE

NONMETALLIC MATERIALS SUPPORTABILITY
Task Order 0001: Nonmetallic Materials Supportability
Project [1-052] The Evaluation of Two-Part Epoxy Paste Adhesives for Repair Bonding of Aluminum Alloys

5a. CONTRACT NUMBER
FA8650-05-D-5610-0001

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
65502F

6. AUTHOR(S)

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5d. PROJECT NUMBER
3005

5e. TASK NUMBER
ML

5f. WORK UNIT NUMBER
X0HY

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER
UDR-TR-2013-62

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

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Air Force Materiel Command
United States Air Force

10. SPONSORING/MONITORING AGENCY ACRONYM(S)
AFRL/RXSA

11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S)
AFRL-RX-WP-TR-2013-0054

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

Approved by 88ABW Public Affairs Office: Case number 88ABW-2013-2083, 3 May 2013. Report contains color.

14. ABSTRACT

A number of epoxy paste adhesives were evaluated as alternatives to Henkel's EA 9320NA for aluminum bonding applications that utilize a nylon pad/sol-gel surface preparation without bond primer. Paste adhesive is currently used in some noncritical aluminum bonding applications for which heating is difficult and bond primer cannot be used. The EA 9320NA exhibits several limitations, including relatively low lap shear strength at elevated temperature, marginal peel strength, and limited pot life once mixed. This report provides results of coupon testing, including environmental durability (wedge test), tensile lap shear, and floating roller peel. Henkel's Hysol EA 9360 paste adhesive appeared to be the best overall candidate for replacing EA 9320NA by exhibiting good environmental durability without EA 9320NA's limitations.

15. SUBJECT TERMS

Adhesive bonding, paste adhesive, bonded repair, prebond surface preparation, sol-gel, aluminum alloys.

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT:	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON (Monitor)
a. REPORT	b. ABSTRACT	c. THIS PAGE			Kara Storage
Unclassified	Unclassified	Unclassified	SAR	58	19b. TELEPHONE NUMBER *(Include Area Code)* (937) 255-7484

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Preface

This report covers work performed by personnel from the University of Dayton Research Institute (UDRI) and the Air Force Research Laboratory's Materials Integrity Branch (AFRL/RXSA) from 01 April 2010 until 30 September 2011. The UDRI work was performed on contract FA8650-05-D-5610, Task Order 0001, Project [1-052] under the direction AFRL/RXSA. Ms. Kara Storage (AFRL/RXSA) was the contract monitor. The AFRL/RXSA project engineers for this effort were Ms. Kara Storage, Mr. Erik Ripberger, and Ms. Megan Shouse. The UDRI Principal Investigator was Mr. Daniel McCray. Mr. Jeffrey Smith of UDRI supported the project by fabricating and testing specimens, compiling data, and analyzing test results. Administrative support was provided by Ms. Jeanne Miller (UDRI) and Ms. Cynthia Smith (UDRI).

1 Summary

The U.S. Air Force currently authorizes use of Henkel's Hysol EA 9320NA epoxy paste adhesive in conjunction with a nylon pad/sol-gel (NPSG) surface preparation for bonded repairs to certain noncritical aluminum aircraft structure. This system was selected based on a significant amount of testing performed by the Air Force Research Laboratory's Materials Integrity Branch (AFRL/RXSA) and Warner Robins Air Logistics Complex's Engineering Directorate (WR-ALC/EN) that showed adequate environmental durability of bonds fabricated using EA 9320NA with the NPSG surface preparation when no bond primer is used in the process. Although EA 9320NA has been successfully used in bonded repairs, several limitations exist when using the adhesive for these applications, including relatively low lap shear strength at elevated temperature, marginal peel strength, and limited pot life once mixed. In response, AFRL/RXSA evaluated additional epoxy paste adhesives in attempts to identify alternative candidates that could minimize current repair application limitations. This report provides results of the coupon testing, including environmental durability (wedge test), tensile lap shear, and floating roller peel. Henkel's Hysol EA 9360 paste adhesive appeared to be the best overall candidate for replacing EA 9320NA.

2 Introduction

The U.S. Air Force currently authorizes the use of Henkel's Hysol EA 9320NA two-part, epoxy paste adhesive for repair bonding of certain noncritical aluminum structures[1]. EA 9320NA adhesive was selected for use with nylon-pad/sol-gel (NPSG) prebond surface preparation (no primer), based primarily on laboratory-scale testing performed by Air Force Research Laboratory's Materials Integrity Branch (AFRL/RXSA) and the University of Dayton Research Institute (UDRI)[2]. The NPSG process and EA 9320NA adhesive were authorized for certain repair applications following testing by Warner Robins Air Logistics Complex's Engineering Directorate (WR-ALC/EN)[3].

Metal bonds can fail in service due to degradation of the metal-polymer interface caused by moisture intrusion into the bondline. Therefore, AFRL/RXSA and UDRI relied heavily on bond environmental durability test results when evaluating candidate adhesives for use with the NPSG process. Environmental durability was assessed via the wedge test per ASTM D3762[4]. Although EA 9320NA generated good wedge test results when used with the NPSG surface preparation, the adhesive is lacking in several other areas, including pot (working) life, peel strength, and elevated-temperature lap shear strength. Due to limitations associated with EA 9320NA, WR-ALC/EN requested support from AFRL/RXSA and UDRI to identify alternative paste adhesives for use with NPSG in repairing aluminum aircraft structures. The goal of the program was to identify alternative adhesives that could be used with NPSG surface preparation to obtain acceptable environmental durability, as determined by the wedge test, while providing increased pot life, exhibiting improved lap shear strength at elevated temperature, and demonstrating as good or better peel strength than EA 9320NA.

3 Methods, Assumptions, and Procedures

Alternative paste adhesives from Henkel and Magnolia Plastics were selected for evaluation in this project based on lap shear and pot life published in the manufacturers' adhesive datasheets (Table 1). Each of the adhesives appears to yield properties similar to or better than those of EA 9320NA. AFRL/RXSA and UDRI developed test matrices to screen those adhesives for use with NPSG surface preparation in two tasks. The first task employed the wedge test to assess bond environmental durability, with results used to select final candidates. Follow-on testing was then performed to evaluate initial strengths and environmental durability of paste adhesive bonds fabricated using multiple adherend surface preparations and adhesive cures. The two tasks are described in the following subsections.

Table 1. Select Adhesive Properties Taken from Manufacturers' Adhesive Datasheets

Adhesive	Lap Shear Strength (psi)		Pot Life at 77°F
	77°F	180°F	
Hysol EA 9320NA (control)	3400	1500	25 minutes for 200 g
Hysol EA 9360	5000	3000	50 minutes for 200 g
Hysol EA 9377	2300	n/a[1]	60 minutes for 100 g
Hysol EA 9380	5350	4200	n/a[1]: requires heat to cure
Magnobond 95	n/a[1]	n/a[1]	120 minutes for 85 g
Magnobond 6168-1[2]	4000	2500	45 minutes for 85 g
Magnobond 6392-2[2]	4500	3200	80 minutes for 85 g
Magnobond 6398[3]	4700	n/a[1]	80 minutes for 85 g
Magnobond 6448	4374	n/a[1]	160 minutes for 454 g
Magnobond 6301	4500	1100	60 minutes for 85 g

Notes: [1] n/a: not available on datasheet
[2] Contains spacer beads for bondline control
[3] Magnobond 6398 is the same as 6392-2 but does not contain spacer beads

3.1 Task #1: Screening

The purpose of screening was to determine how each candidate adhesive performed with NPSG surface preparation as assessed by the wedge test. Wedge test specimens were fabricated from panels bonded by three individuals with varying degrees of experience. Each person fabricated two wedge test panels with each adhesive, one using 5-mil (0.005-inch) diameter glass beads for bondline control and the other using 5-mil polyester random mat scrim cloth. Wedge test panels were fabricated using 0.125-inch thick 2024-T3 bare aluminum adherends. The screening test matrix is provided in Table 2.

3.1.1 NPSG Surface Preparation

Adherends were degreased using acetone-soaked, lint-free wipes until all visible trace of contamination was removed. The bond surfaces were abraded with very fine (VFN) Scotch-Brite™ Roloc™ surface conditioning discs using a high-speed grinder powered by clean, dry air. Surfaces were abraded for approximately 1 minute (nominal) per 6-inch by 6-inch area. Abrasion debris was removed from the bond surfaces using clean, dry, pressurized air (35 psi). 3M Company's AC®-130-2 sol-gel solution was applied to the bond surfaces using a clean acid

brush. The surfaces were wetted for 3-4 minutes. Panels were drained vertically and then dried at ambient conditions for 60 minutes. Ambient conditions during this effort were recorded between 62-74 degrees Fahrenheit (°F) and 24-69% relative humidity (RH). Adhesive was applied within 3 hours after surface treatment with AC-130-2.

Table 2. Screening Test Matrix

Adhesive	Bondline Control	Number of Wedge Specimens		
		Shouse	Ripberger	Smith
EA 9360	5-mil Glass Spacer Beads	5	5	5
	Polyester Scrim Cloth	5	5	5
EA 9377	5-mil Glass Spacer Beads	5	5	5
	Polyester Scrim Cloth	5	5	5
EA 9380	5-mil Glass Spacer Beads	5	5	5
	Polyester Scrim Cloth	5	5	5
EA 9320NA	5-mil Glass Spacer Beads	5	5	5
	Polyester Scrim Cloth	5	5	5
Magnobond 6168-1	Glass Beads Included in Adhesive by Manufacturer	5	5	5
Magnobond 6392-2		5	5	5
Magnobond 6398	5-mil Glass Spacer Beads	5	5	5
	Polyester Scrim Cloth	5	5	5
Magnobond 6448	5-mil Glass Spacer Beads	5	5	5
	Polyester Scrim Cloth	5	5	5
Magnobond 6301	5-mil Glass Spacer Beads	5	5	5
	Polyester Scrim Cloth	5	5	5

3.1.2 Adhesive Application and Cure Procedures

Adhesives were mixed per the manufacturers' recommendations. When required for bondline control, 5-mil glass beads were mixed with the adhesives in the amount of 5% by mass. Magnolia's Magnobond 6168-1 and 6392-2 were manufactured with glass spacer beads, therefore no additional beads were added during mixing. Polyester random mat scrim cloth (5-mil thick) was used for bondline control when fabricating specimens without glass spacer beads. Mixed adhesive was applied to both adherends using a razor blade. When scrim cloth was required for bondline control, it was placed onto one of the coated adherends and a second layer of adhesive was applied over the scrim cloth. Adherends were placed together and taped to prevent shifting during cure. The wedge test panels were cured in a vacuum bag at elevated temperature using the cure cycles provided in the following subsections.

3.1.2.1 EA 9360, EA 9377, EA 9320NA, Magnobond 6392-2, 6398, and 6448 Cure

Wedge test panels bonded with Hysol EA 9360, EA 9377, and EA 9320NA, as well as Magnobond 6392-2, 6398, and 6448 adhesives, were all cured using the same elevated-temperature, partial vacuum cure cycle. Full vacuum (26 inches Hg minimum) was applied to seal the vacuum bag. Vacuum was then reduced to 15 inches Hg and held at that pressure throughout the remainder of the cure cycle. The panels were heated at 5°F per minute to 180°F

and held for 70 minutes. The wedge test panels were cooled at 5°F per minute to 150°F prior to venting vacuum.

3.1.2.2 EA 9380 Cure

Wedge test panels bonded with Hysol EA 9380 were cured at elevated temperature under partial vacuum pressure. Full vacuum (26 inches Hg minimum) was applied to seal the vacuum bag. Vacuum was then reduced to 15 inches Hg and held at that pressure throughout the remainder of the cure cycle. The panels were heated at 5°F per minute to 170°F and held for 70 minutes. The wedge test panels were cooled at 5°F per minute to 150°F prior to venting vacuum.

3.1.2.3 Magnobond 95 Cure

Wedge test panels bonded with Magnobond 95 were cured using the manufacturer's recommended temperature profile with partial vacuum pressure applied for consolidation. Full vacuum (26 inches Hg minimum) was applied to seal the vacuum bag. Vacuum was then reduced to 15 inches Hg and held at that pressure throughout the remainder of the cure cycle. The panels were held overnight (12-24 hours) at 75°F prior to being heated at 5°F per minute to 200°F and held at that temperature for 2 hours. The panels were then heated at 5°F per minute to 350°F and held there for 60 minutes. Panels were cooled at 5°F per minute to 150°F prior to venting the vacuum.

3.1.2.4 Magnobond 6181-1 and 6301 Cure

Wedge test panels bonded with Magnobond 6181-1 and 6301 adhesives were cured using the same elevated-temperature, partial vacuum pressure cure cycle. Full vacuum (26 inches Hg minimum) was applied to seal the vacuum bag. Vacuum was then reduced to 15 inches Hg and held at that pressure throughout the remainder of the cure cycle. The panels were heated at 5°F per minute to 140°F and held for 70 minutes. The wedge test panels were cooled at 5°F per minute to 150°F prior to venting the vacuum.

3.1.3 Wedge Test Procedures

Wedge test panels were machined into 1.00-inch wide specimens using a horizontal mill. Specimen edges were polished and adhesive bondline thicknesses were measured using a microscope. Wedges were driven into the ends of the specimens using a hammer. Specimens were stored at ambient temperature for 12 hours prior to measuring the initial crack from the shoulder of the wedge. Specimens were placed into a humidity cabinet preset to 120°F and 95-100% RH. Crack length was measured after 4 hours, 24 hours, 7 days, 14 days, 21 days, and 28 days of exposure. Wedge test specimens were split apart after 28 days to determine failure modes. Failure mode was determined as the percentage of the test area that failed cohesively within the adhesive. The test area was defined as the area of the full-width wedge test specimen between the initial crack and final crack locations.

3.2 Task #2: Follow-On Adhesive Evaluations

Based on wedge test screening results from Task #1 (Section 4.1), the following adhesives were selected for further evaluation: EA 9360, EA 9380, EA 9377, Magnobond 6392-2, and Magnobond 6398. EA 9380 was evaluated strictly for elevated-temperature cures since it cannot

cure at ambient temperature. EA 9377 was evaluated as a liquid shim compound. Magnobond 6392-2 and Magnobond 6398 are the same adhesive with the exception 6392-2 is manufactured with glass spacer beads. EA 9320NA was also tested as a control. The adhesives were evaluated in a manner similar to that used by AFRL/RXSA during an earlier paste adhesive evaluation program[2]. The basic test matrix used to evaluate the paste adhesives is shown in Table 3. This matrix was repeated for each of the different adhesives, except EA 9380 specimens were only fabricated using the elevated-temperature cures. Adherends were 2024-T3 bare aluminum. Bondline control was achieved through the use of 5-mil polyester random mat scrim cloth for all specimens with the exception of Magnobond 6392-2, which already contained glass spacer beads.

Table 3. Follow-On Adhesive Evaluation Test Matrix

Surface Preparation	Cure Cycle	Number of Specimens				
		Wedge Test	Lap Shear Test			Peel Test
		120°F	75°F	160°F	180°F	75°F
PAA with BR 127 Primer	ET-PP[1]	5	5	5	5	5
	ET-V[2]	5	5	5	5	5
	AT-PP[3]	5	5	5	5	5
	AT-V[4]	5	5	5	5	5
NPSG	ET-PP[1]	5	5	5	5	5
	ET-V[2]	5	5	5	5	5
	AT-PP[3]	5	5	5	5	5
	AT-V[4]	5	5	5	5	5
Scuff-sand / solvent wipe	ET-V[2]	5	5	5	5	5

Notes: [1] ET-PP: Elevated temperature-positive pressure cure
[2] ET-V: Elevated temperature-vacuum cure
[3] AT-PP: Ambient temperature-positive pressure cure
[4] AT-V: Ambient temperature-vacuum cure

3.2.1 Surface Preparation Procedures

Three prebond surface preparations were used to evaluate the candidate adhesives: phosphoric acid anodize (PAA) with Cytec Engineered Materials BR 127 corrosion-inhibiting adhesive primer, NPSG, and scuff-sand/solvent wipe. No primer was used with NPSG or scuff-sand/solvent wipe processes. These three surface preparations provided a range of performance for bonded joints that could be encountered in a repair environment, with PAA being the best process, scuff-sand/solvent wipe being the worst process, and NPSG falling somewhere in between.

PAA was performed in accordance with ASTM D3933[5]. Once anodized, the adherends were primed with BR 127 adhesive primer applied via spray gun to a nominal thickness of 0.0002 inch. Primed parts were dried at ambient laboratory conditions for 30 minutes then cured in a preheated, air-circulating oven for 60 minutes at 250°F.

The NPSG process was performed as described in Section 3.1.1.

The scuff-sand/solvent wipe process was performed by initially cleaning the aluminum substrates using acetone-soaked, lint-free wipes until all visible trace of contamination was removed. Adherends were abraded with 100-grit aluminum oxide abrasive paper using a random orbital sander. The substrates were then cleaned with acetone-soaked, lint-free wipes after abrasion. Adherends were bonded and cured within 2 hours of abrasion.

3.2.2 Adhesive Application and Cure Procedures

Adhesives were mixed per the manufacturers' recommendations. Polyester random mat scrim cloth was used for bondline control for all the adhesives with the exception of Magnobond 6392-2, which already contained glass spacer beads. Mixed adhesive was applied to both of the adherends using a razor blade. Scrim cloth was placed onto one of the coated adherends, and a second layer of adhesive was applied over the scrim cloth. Adherends were placed together and taped to prevent shifting during cure. Test panels were cured in an autoclave or vacuum bag using one of the cure cycles provided in the following subsections.

3.2.3 Adhesive Cure Cycles

Four basic cure cycles were used to bond specimens in this task: an elevated temperature-positive pressure cure (ET-PP), an elevated temperature-vacuum cure (ET-V), an ambient temperature-positive pressure cure (AT-PP), and an ambient temperature-vacuum cure (AT-V).

3.2.3.1 ET-PP Cure Cycle

All adhesives, with the exception of EA 9380, were cured using the same elevated-temperature cure cycle under 35 psi positive pressure. Pressure was applied at the start of the cure and maintained throughout. Test panels were heated at 5°F per minute to 180°F and held for 70 minutes. The test panels were cooled at 5°F per minute to 150°F prior to releasing pressure.

EA 9380 test panels were cured by applying 35 psi positive pressure and maintaining throughout the cure. Panels were heated at 5°F per minute to 175°F and held for 4 hours. The test panels were cooled at 5°F per minute to 150°F prior to releasing pressure.

3.2.3.2 ET-V Cure Cycle

The ET-V cure cycles were the same as those described above for the ET-PP cure cycle with the exception vacuum pressure was used rather than positive pressure. Vacuum pressure of 15 inches Hg was maintained throughout the cure.

3.2.3.3 AT-PP Cure Cycle

All adhesives were cured using the AT-PP cycle with the exception of EA 9380, which does not cure at ambient temperature. Pressure of 35 psi was applied at the start of the cure and maintained for 24 hours. Pressure was vented and the test panels remained at ambient laboratory conditions for an additional five days prior to machining.

3.2.3.4 AT-V Cure Cycle

The AT-V cure cycle was identical to the AT-PP cure cycle with the exception vacuum pressure was used versus positive pressure. Vacuum pressure of 15 inches Hg was maintained throughout the cure.

3.2.4 Test Method Descriptions

The following tests were performed in this task: wedge testing per ASTM D3762, tensile lap shear per ASTM D1002[6], and floating roller peel per ASTM D3167[7].

Wedge tests were performed as described in Section 3.1.3 with specimens exposed to 120°F and 95-100% RH for 28 days.

Tensile lap shear testing was performed in accordance with ASTM D1002. Specimens were machined from the test panels using a horizontal mill, their edges were polished, and adhesive bondlines were measured using an optical microscope. Lap shear specimens were soaked at the test temperature for 10 minutes prior to testing. Failure modes were determined after testing and expressed as the percentage of bond area failing cohesively within the adhesive.

Floating roller peel testing was performed in accordance with ASTM D3167. Specimens were machined from test panels using a shear, their ends were polished, and adhesive bondlines were measured using an optical microscope. Peel specimens were tested at ambient laboratory conditions. Failure modes were determined after testing and expressed as the percentage of bond area that failed cohesively within the adhesive.

4 Results and Discussion

4.1 Task #1: Screening Results

Results from the screening wedge tests are provided in the following subsections and are sorted by adhesive. Individual specimen test results are provided in Appendix A.

4.1.1 EA 9320NA (Control) Screening Wedge Test Results

A summary of wedge test results using EA 9320NA adhesive and the NPSG surface preparation are provided in Table 4. In general, EA 9320NA specimens failed primarily in a cohesive manner within the adhesive when scrim cloth was used for bondline control. However, use of glass spacer beads resulted in a significant change in failure mode, with failures occurring at the adhesive-aluminum interface. The EA 9320NA wedge test failure modes correspond well with previous AFRL/RXSA results when using scrim cloth[2].

Table 4. EA 9320NA Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Person A	1.57	0.00	0.09	0.11	0.16	0.16	0.16	92%
	Person B	1.66	0.04	0.09	0.13	0.14	0.14	0.16	76%
	Person C	1.62	0.08	0.10	0.14	0.17	0.18	0.21	96%
Glass Beads	Person A	1.60	0.19	0.29	0.39	0.49	0.50	0.50	16%
	Person B	1.60	0.07	0.11	0.17	0.21	0.23	0.25	32%
	Person C	1.63	0.16	0.19	0.26	0.29	0.37	0.39	0%

Note: Failure mode recorded as % of test area failing cohesively within the adhesive (% coh.).

4.1.2 EA 9360 Screening Wedge Test Results

EA 9360 wedge test results using the NPSG surface preparation are provided in Table 5. Initial cracks observed in EA 9360 specimens were similar to those observed with EA 9320NA. EA 9360 failure modes were vastly improved over those of EA 9320NA when using glass spacer beads for bondline control. Improvements in failure modes were also observed with EA 9360 when using scrim cloth. EA 9360 appeared to be a viable candidate for further evaluation.

Table 5. EA 9360 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Person A	1.66	0.07	0.17	0.29	0.31	0.32	0.35	99%
	Person B	1.61	0.00	0.03	0.03	0.06	0.06	0.07	99%
	Person C	1.58	0.02	0.03	0.09	0.12	0.13	0.16	71%
Glass Beads	Person A	1.49	0.03	0.08	0.13	0.15	0.16	0.16	56%
	Person B	1.82	0.00	0.00	0.00	0.01	0.01	0.01	87%
	Person C	1.62	0.00	0.00	0.00	0.03	0.03	0.05	78%

4.1.3 EA 9377 Screening Wedge Test Results

EA 9377 wedge test results are provided in Table 6. EA 9377 initial cracks are significantly longer than those observed with EA 9320NA and, therefore, less stress was applied to the interface during testing. However, EA 9377 failure modes were deemed to be excellent whether scrim cloth or glass spacer beads were used for bondline control. Although the initial cracks were longer than desired, EA 9377 was further evaluated mainly due to its potential use as a liquid shim rather than as a replacement for EA 9320NA.

Table 6. EA 9377 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Person A	2.26	0.16	0.20	0.31	0.35	0.35	0.39	100%
	Person B	2.50	0.08	0.12	0.12	0.14	0.14	0.15	100%
	Person C	2.40	0.03	0.04	0.06	0.06	0.07	0.07	100%
Glass Beads	Person A	2.65	0.31	0.35	0.38	0.40	0.43	0.43	99%
	Person B	2.32	0.15	0.18	0.20	0.23	0.24	0.25	100%
	Person C	2.41	0.02	0.04	0.07	0.08	0.11	0.11	100%

4.1.4 EA 9380 Screening Wedge Test Results

EA 9380 was evaluated for use even though it is only capable of elevated-temperature cure. Wedge test results for EA 9380 are provided in Table 7. Initial cracks observed in EA 9380 wedge test specimens were similar in length to those observed for EA 9320NA wedge test specimens. In addition, failure modes witnessed in EA 9380 wedge test specimens were considered excellent whether scrim cloth or glass spacer beads were used for bondline control. EA 9380 wedge test results were significantly better than those achieved using EA 9320NA. Therefore, EA 9380 was further evaluated for use in replacing EA 9320NA for applications that can take advantage of elevated-temperature curing.

Table 7. EA 9380 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Person A	1.71	0.00	0.01	0.01	0.02	0.02	0.02	100%
	Person B	1.59	0.00	0.02	0.02	0.02	0.02	0.03	100%
	Person C	1.54	0.01	0.01	0.01	0.02	0.04	0.04	100%
Glass Beads	Person A	1.54	0.00	0.04	0.07	0.07	0.07	0.07	99%
	Person B	1.68	0.00	0.02	0.04	0.07	0.07	0.07	100%
	Person C	1.54	0.01	0.01	0.01	0.01	0.01	0.01	100%

4.1.5 Magnobond 95 Screening Wedge Test Results

Wedge test results for Magnobond 95 are provided in Table 8. Magnobond 95 was extremely thick and viscous, proving difficult to apply to the substrates. Based on difficulties mixing and applying Magnobond 95, none of the personnel fabricated specimens using glass beads for bondline control, and Person A did not fabricate specimens using scrim cloth. Although failure modes of Magnobond 95 wedge test specimens were virtually 100% cohesive, the adhesive was not considered for further evaluation due to the handling issues. In addition, the initial crack lengths were considered too large to adequately stress the interface during testing; this likely contributed to the favorable wedge test failure modes.

Table 8. Magnobond 95 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim Cloth	Person A	2.57	0.03	0.04	0.04	0.05	0.05	0.05	99%
	Person B	2.44	0.01	0.02	0.02	0.04	0.05	0.10	100%

4.1.6 Magnobond 6168-1 Screening Wedge Test Results

Magnobond 6168-1 wedge test results are provided in Table 9. Specimens were not fabricated with scrim cloth since Magnobond 6168-1 contains glass spacer beads. Failure modes observed in Magnobond 6168-1 specimens were primarily at the adhesive-aluminum interface. Magnobond 6168-1 was not considered for further evaluation due to these poor failure modes.

Table 9. Magnobond 6168-1 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Glass Beads[1]	Person A	1.84	0.11	0.12	0.14	0.14	0.18	0.20	15%
	Person B	1.62	0.15	0.16	0.27	0.29	0.30	0.30	20%
	Person C	1.57	0.02	0.02	0.06	0.09	0.12	0.18	20%

Note: [1]Glass spacer beads were included in the adhesive as received from the manufacturer

4.1.7 Magnobond 6392-2 Screening Wedge Test Results

Magnobond 6392-2 wedge test results are provided in Table 10. Wedge test specimens were not fabricated using scrim cloth since Magnobond 6392-2 contains glass spacer beads. Initial crack lengths of the Magnobond 6392-2 wedge test specimens were approximately 0.25 inches longer than those of EA 9320NA specimens. Failure modes observed in the Magnobond 6392-2 wedge test specimens were favorable as compared to the failure modes of the EA 9320NA specimens utilizing glass spacer beads for bondline control, so Magnobond 6392-2 was further evaluated.

Table 10. Magnobond 6392-2 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Glass Beads[1]	Person A	1.87	0.01	0.06	0.12	0.14	0.15	0.17	94%
	Person B	1.81	0.00	0.05	0.06	0.07	0.07	0.08	100%
	Person C	1.87	0.03	0.05	0.06	0.07	0.09	0.11	92%

Note: [1]Glass beads were included in the adhesive as received from the manufacturer

4.1.8 Magnobond 6398 Screening Wedge Test Results

Wedge test results for specimens bonded with Magnobond 6398 adhesive are provided in Table 11. Initial crack lengths observed in Magnobond 6398 specimens were approximateky 0.25 inches longer than those of the EA 9320NA specimens, and Magnobond 6398 wedge test specimens exhibited higher percentages of cohesive failure than did those of the EA 9320NA specimens. Wedge test results of Magnobond 6398 were similar to those of Magnobond 6392-2. This was expected since Magnobond 6392-2 is the same adhesive as Magnobond 6398 but supplied with glass spacer beads. Magnobond 6398 was selected for further evaluation.

Table 11. Magnobond 6398 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Person A	1.95	0.05	0.09	0.12	0.14	0.14	0.16	92%
	Person B	2.22	0.01	0.02	0.05	0.05	0.05	0.05	100%
	Person C	1.79	0.00	0.00	0.06	0.09	0.13	0.13	100%
Glass Beads	Person A	1.77	0.04	0.05	0.10	0.12	0.12	0.12	97%
	Person B	1.97	0.05	0.07	0.22	0.30	0.33	0.34	86%
	Person C	1.87	0.00	0.00	0.03	0.09	0.09	0.10	81%

4.1.9 Magnobond 6448 Screening Wedge Test Results

Magnobond 6448 wedge test results are provided in Table 12. Initial crack lengths observed in the Magnobond 6448 specimens were significantly higher than those witnessed with EA 9320NA, thus leading to less stress applied to the interface during testing. Specimens fabricated using glass spacer beads for bondline control exhibited substantial failure at the adhesive-aluminum interface. Use of scrim cloth for bondline control improved the failure modes considerably. Magnobond 6448 was not selected for further evaluation based on the poor failure modes observed for the wedge test specimens fabricated using glass beads for bondline control.

4.1.10 Magnobond 6301 Screening Wedge Test Results

Wedge test results for Magnobond 6301 are provided in Table 13. Initial cracks observed in the Magnobond 6448 specimens were significantly longer than those witnessed in EA 9320NA specimens. In addition, significant amounts of failure occurred at the adhesive-aluminum interface in the Magnobond 6301 specimens fabricated with glass beads. Although cohesive

failures were observed using scrim cloth, Magnobond 6301 was not evaluated further due to the poor failure modes observed when used with glass beads for bondline control.

Table 12. Magnobond 6448 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Person A	2.34	0.01	0.03	0.05	0.08	0.08	0.08	98%
	Person B	1.90	0.00	0.02	0.06	0.09	0.09	0.11	99%
	Person C	1.84	0.00	0.01	0.10	0.13	0.16	0.16	96%
Glass Beads	Person A	2.06	0.17	0.24	0.30	0.34	0.35	0.35	41%
	Person B	2.13	0.17	0.25	0.35	0.38	0.38	0.40	51%
	Person C	2.04	0.00	0.00	0.01	0.03	0.08	0.09	96%

Table 13. Magnobond 6301 Screening Wedge Test Results (120°F and 95-100% RH)

Bondline Control	Fabricator	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Person A	1.98	0.00	0.07	0.10	0.11	0.12	0.14	98%
	Person B	1.94	0.05	0.10	0.14	0.15	0.16	0.17	97%
	Person C	1.98	0.16	0.16	0.20	0.20	0.22	0.25	99%
Glass Beads	Person A	1.75	0.34	0.36	0.49	0.59	0.64	0.68	0%
	Person B	1.89	0.20	0.22	0.27	0.28	0.30	0.31	5%
	Person C	2.11	0.29	0.31	0.32	0.32	0.32	0.35	40%

4.2 Task #2: Follow-On Adhesive Evaluation Results

Follow-on test results are provided in the following subsections and are sorted by adhesive. Individual specimen test results are provided in Appendix B.

4.2.1 EA 9320NA Test Results

Tensile lap shear and peel test results for EA 9320NA are provided in Table 14. Failures occurred cohesively within the adhesive, unless otherwise noted. PAA/BR 127 specimens exhibited the highest strengths, all failing cohesively within the adhesive. Specimens prepared with scuff-sand/solvent wipe generally exhibited the lowest strengths and poorest failure modes with substantial failure occurring at the adhesive-aluminum interface. Specimens prepared using the NPSG process generally exhibited strength values falling between those observed with PAA/BR 127 and scuff-sand/solvent wipe. This overall trend was witnessed in the original paste adhesive evaluations[2]. However, the elevated-temperature lap shear strengths observed in the EA 9320NA bonded specimens with NPSG-treated adherends were considerably lower in this evaluation when compared to the earlier work[2]. Reasons for this are unknown, but they are concerning since EA 9320NA is currently used with NPSG for field-level bonded repairs.

Table 14. EA 9320NA Lap Shear and Peel Test Results

Surface Preparation	Cure Cycle	Lap Shear Strength, psi			Peel Strength, pli
		75°F	160°F	180°F	75°F
PAA with BR 127 Primer	ET-PP	5835	3575	2510	38.4
	ET-V	5091	2962	1950	39.4
	AT-PP	5209	2407	1655	37.3
	AT-V	4709	1879	1434	37.3
NPSG	ET-PP	4238	1793[m]	741[i]	24.5[m]
	ET-V	3699	369	207	21.9
	AT-PP	4029	1504	780 [m]	31.6
	AT-V	3348	1389	595[m]	32.8
Scuff-sand / solvent wipe	ET-V	3635	1431[m]	543[i]	3.7[i]

Notes: [i] interfacial failure
[m] mixed failure mode (areas of cohesive and interfacial failure within specimen)

EA 9320NA follow-on wedge test results are provided in Table 15. The PAA/BR 127 process yielded cohesive failures, regardless of adhesive cure. Traditionally, EA 9320NA adhesive provided cohesive failure modes when used with NPSG surface preparation and scrim cloth as bondline control, as witnessed in Section 4.1.1 and previous programs[2]. However, excessive interfacial failures were observed with EA 9320NA specimens when using the NPSG. The scuff-sand/solvent wipe process yielded failures at the adhesive-aluminum interface, as expected.

Table 15. EA 9320NA Follow-On Wedge Test Results (120°F and 95-100% RH)

Surface Preparation	Cure Cycle	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA with BR 127 Primer	ET-PP	1.55	0.02	0.05	0.10	0.11	0.11	0.13	100%
	ET-V	1.56	0.06	0.06	0.12	0.15	0.15	0.15	100%
	AT-PP	1.57	0.42	0.42	0.42	0.42	0.42	0.42	100%
	AT-V	1.53	0.07	0.07	0.08	0.08	0.08	0.10	100%
NPSG	ET-PP	1.57	0.11	0.22	0.32	0.42	0.44	0.45	6%
	ET-V	1.98	0.21	0.21	0.21	0.21	0.21	0.21	100%
	AT-PP	1.61	0.16	0.20	0.29	0.37	0.40	0.41	20%
	AT-V	1.57	0.11	0.16	0.20	0.24	0.24	0.24	84%
Scuff-sand / solvent wipe	ET-V	2.14	0.86	0.86	0.86	0.87	0.92	0.92	0%

4.2.2 EA 9360 Test Results

Tensile lap shear and floating roller peel test results for EA 9360 are provided in Table 16. Failure occurred cohesively within the adhesive, unless otherwise noted. EA 9360 specimens generally exhibited higher strengths than those observed with EA 9320NA. This was especially true when comparing lap shear strengths at elevated temperature and when using the NPSG

process. The mixed failure modes observed in the 180°F-lap shear tests were mostly cohesive in nature with less than 25% by area interfacial failure. These strengths and failures were considerably better than those observed with EA 9320NA.

Table 16. EA 9360 Lap Shear and Peel Test Results

Surface Preparation	Cure Cycle	Lap Shear Strength, psi			Peel Strength, pli
		75°F	160°F	180°F	75°F
PAA with BR 127 Primer	ET-PP	5264	4373	3745	35.6
	ET-V	5777	4101	3321	37.0
	AT-PP	5100	3178	3171	42.2
	AT-V	5043	2938	2791[m]	45.2
NPSG	ET-PP	4560	3345	2875[m]	32.4
	ET-V	4595	3295	2680	35.7
	AT-PP	4379	2683	2390[m]	43.5
	AT-V	4291	2738	2205[m]	46.8
Scuff-sand / solvent wipe	ET-V	4066	3044[m]	2419[m]	23.0[m]

Notes: [m] mixed failure mode (areas of cohesive and interfacial failure within specimen)

Follow-on wedge test results for EA 9360 are provided in Table 17. All specimens failed predominantly cohesively (within the adhesive) with the exception of specimens prepared using the scuff-sand/solvent wipe process. The NPSG specimens bonded with EA 9360 outperformed NPSG specimens bonded with EA 9320NA.

Table 17. EA 9360 Follow-On Wedge Test Results (120°F and 95-100% RH)

Surface Preparation	Cure Cycle	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA with BR 127 Primer	ET-PP	1.58	0.00	0.00	0.04	0.05	0.05	0.05	100%
	ET-V	1.54	0.00	0.00	0.03	0.03	0.03	0.03	100%
	AT-PP	1.48	0.13	0.13	0.13	0.13	0.15	0.15	100%
	AT-V	1.60	0.03	0.03	0.03	0.04	0.04	0.04	100%
NPSG	ET-PP	1.59	0.01	0.05	0.06	0.06	0.06	0.06	100%
	ET-V	1.55	0.00	0.00	0.03	0.08	0.08	0.08	100%
	AT-PP	1.62	0.07	0.07	0.09	0.12	0.14	0.14	98%
	AT-V	1.49	0.02	0.02	0.05	0.07	0.12	0.15	97%
Scuff-sand / solvent wipe	ET-V	1.59	0.95	0.95	0.95	0.95	0.96	0.96	19%

4.2.3 EA 9380 Test Results

Lap shear and peel test results for EA 9380 are provided in Table 18. All specimens failed cohesively within the adhesive, unless otherwise noted. Specimens were not fabricated using the

ambient-temperature cure since EA 9380 requires elevated-temperature to cure. NPSG specimens exhibited similar strengths and failure modes to those achieved with PAA/BR 127, with the exception of floating roller peel strengths. Specimens prepared using the scuff-sand/solvent wipe process yielded substantial amounts of interfacial failure and lower strengths than those fabricated with the PAA/BR 127 and NPSG processes. EA 9380 adhesive provided better lap shear strengths but reduced peel strengths when compared to EA 9320NA.

Table 18. EA 9380 Lap Shear and Peel Strength Test Results

Surface Preparation	Cure Cycle	Lap Shear Strength, psi			Peel Strength, (pli)
		75°F	160°F	180°F	75°F
PAA with BR 127 Primer	ET-PP	5497	3771	3076	35.3
	ET-V	3959	2653	2336	36.9
NPSG	ET-PP	4063	3639	2916	13.9
	ET-V	3685	2626	2177	24.4[m]
Scuff-sand / solvent wipe	ET-V	2533[m]	2320[m]	1988[m]	3.6[i]

Notes: [m] mixed failure mode (areas of cohesive and interfacial failure within specimen)
[i] interfacial failure at adhesive-aluminum interface

EA 9380 follow-on wedge test results are provided in Table 19. All specimens fabricated using PAA/BR 127 and NPSG failed cohesively. The scuff-sand/solvent wipe specimens failed at the adhesive-aluminum interface. The failure modes for the PAA/BR 127 and NPSG specimens were better than those observed for the analogous EA 9320NA specimens.

Table 19. EA 9380 Follow-On Wedge Test Results (120°F and 95-100% RH)

Surface Preparation	Cure Cycle	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA with BR 127 Primer	ET-PP	1.57	0.00	0.00	0.00	0.01	0.01	0.01	100%
	ET-V	1.59	0.00	0.00	0.00	0.00	0.00	0.00	100%
NPSG	ET-PP	1.58	0.00	0.00	0.00	0.00	0.00	0.00	100%
	ET-V	1.61	0.00	0.00	0.02	0.05	0.05	0.05	100%
Scuff-sand / solvent wipe	ET-V	3.08	0.96	1.34	1.38	1.38	1.42	1.42	0%

4.2.4 EA 9377 Test Results

Lap shear and peel test results for EA 9377 are provided in Table 20. All specimens failed cohesively within the adhesive, unless otherwise noted. EA 9377 did not provide strengths similar to those of EA 9320NA, which is not entirely unexpected since EA 9377 is a liquid shim compound. The PAA/BR 127 and NPSG specimens all failed cohesively while the scuff-sand/solvent wipe specimens failed at the adhesive-aluminum interface.

Table 20. EA 9377 Lap Shear and Peel Test Results

Surface Preparation	Cure Cycle	Lap Shear Strength, psi			Peel Strength, pli
		75°F	160°F	180°F	75°F
PAA with BR 127 Primer	ET-PP	2505	2275	2278	3.6
	ET-V	2171	1855	1800	3.3
	AT-PP	2412	1722	1261	4.3
	AT-V	2687	1885	2083	3.8
NPSG	ET-PP	2337	1917	1993	4.2
	ET-V	2266	2035	1966	3.5
	AT-PP	2340	2111	1791	5.1
	AT-V	2582	1911	2114	4.4
Scuff-sand / solvent wipe	ET-V	740[i]	626[i]	494[i]	4.2[i]

Notes: [i] interfacial failure at adhesive-aluminum interface

EA 9377 follow-on wedge test results are provided in Table 21. All PAA/BR 127 and NPSG specimens failed cohesively, although initial cracks were significantly longer than those observed with EA 9320NA. The scuff-sand/solvent wipe specimens fell apart while driving the wedges, with the failures located at the adhesive-aluminum interface.

Table 21. EA 9377 Follow-On Wedge Test Results (120°F and 95-100% RH)

Surface Preparation	Cure Cycle	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hr	24 Hr	7 Days	14 Days	21 Days	28 Days	
PAA with BR 127 Primer	ET-PP	2.25	0.06	0.08	0.09	0.09	0.10	0.10	100%
	ET-V	2.43	0.02	0.03	0.03	0.03	0.03	0.05	100%
	AT-PP	2.23	0.14	0.14	0.15	0.18	0.20	0.21	100%
	AT-V	2.01	0.09	0.12	0.14	0.14	0.15	0.15	100%
NPSG	ET-PP	2.32	0.03	0.04	0.04	0.06	0.06	0.06	100%
	ET-V	2.25	0.02	0.04	0.04	0.05	0.05	0.05	100%
	AT-PP	2.47	0.03	0.04	0.04	0.06	0.07	0.07	100%
	AT-V	2.12	0.03	0.06	0.11	0.11	0.12	0.12	100%
Scuff-sand / solvent wipe	ET-V	Fell apart while driving the wedges							0%

4.2.5 Magnobond 6392-2 Test Results

Magnobond 6392-2 lap shear and peel test results are provided in Table 22. Specimens failed cohesively within the adhesive, unless otherwise noted. Since Magnobond 6392-2 contains glass spacer beads, polyester scrim was not used for bondline control. The PAA/BR 127 and NPSG specimens failed cohesively; however, the NPSG specimens generally exhibited lower strengths than those achieved with PAA/BR 127. The specimens prepared with the scuff-sand/solvent wipe process exhibited significantly reduced peel strengths accompanied by complete interfacial

failure. Magnobond 6392-2 provided improved lap shear strengths but lower peel strengths when compared to EA 9320NA.

Table 22. Magnobond 6392-2 Lap Shear and Peel Test Results

Surface Preparation	Cure Cycle	Lap Shear Strength, psi			Peel Strength, pli
		75°F	160°F	180°F	75°F
PAA with BR 127 Primer	ET-PP	5167	4271	3457	28.8
	ET-V	3982	3178	2997	24.5
	AT-PP	5063	2492	2155	35.8
	AT-V	4243	2384	2064	37.5
NPSG	ET-PP	3807	1480	1842	18.1
	ET-V	3332	1969	1426	17.4
	AT-PP	3604	1884	1412	32.3
	AT-V	2551	2037	1573	28.6
Scuff-sand / solvent wipe	ET-V	3150[m]	1372	1542	3.0[i]

Notes: [m] mixed failure mode (areas of cohesive and interfacial failure within specimen)
[i] interfacial failure at adhesive-aluminum interface

Magnobond 6392-2 follow-on wedge test results are provided in Table 23. PAA/BR 127 specimens failed cohesively within the adhesive. The NPSG specimen failure modes were mixed, with most specimens exhibiting large areas of interfacial failure between the adhesive and aluminum. These results do not compare well to the Magnobond 6398 initial screening wedge test results provided in Table 11, which were cohesive in nature. The reason for the difference is unknown.

Table 23. Magnobond 6392-2 Follow-On Wedge Test Results (120°F and 95-100% RH)

Surface Preparation	Cure Cycle	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA with BR 127 Primer	ET-PP	1.78	0.00	0.00	0.02	0.05	0.09	0.09	100%
	ET-V	1.85	0.00	0.00	0.01	0.01	0.01	0.02	100%
	AT-PP	1.68	0.02	0.03	0.06	0.10	0.19	0.20	100%
	AT-V	1.66	0.03	0.03	0.03	0.03	0.08	0.09	100%
NPSG	ET-PP	1.79	0.03	0.04	0.12	0.14	0.18	0.18	34%
	ET-V	1.79	0.05	0.09	0.15	0.17	0.18	0.18	66%
	AT-PP	1.68	0.16	0.30	0.69	0.79	0.79	0.83	0%
	AT-V	1.71	0.03	0.04	0.07	0.15	0.20	0.24	36%
Scuff-sand / solvent wipe	ET-V	2.57	1.00	1.00	1.04	1.08	1.08	1.08	0%

4.2.6 Magnobond 6398 Test Results

Magnonbond 6398 lap shear and peel test results are provided in Table 24. The PAA/BR 127 specimens failed cohesively within the adhesive. The NPSG specimens generally failed cohesively when tested at ambient temperature and exhibited mixed failure modes (combination of cohesive and interfacial failure) at elevated temperature. The scuff-sand/solvent wipe specimens exhibited adhesive-aluminum interfacial failures. Magnobond 6398 generally provided strengths similar to those achieved with Magnobond 6392-2. However, Magnobond 6398 specimens exhibited more interfacial failure than those bonded with Magnobond 6392-2 when used with the NPSG surface preparation. The comparable strengths were expected since 6392-2 and 6398 are the same adhesives except Magnobond 6392-2 is manufactured with glass spacer beads.

Table 24. Magnobond 6398 Lap Shear and Peel Test Data

Surface Preparation	**Cure Cycle**	**Lap Shear Strength, psi**			**Peel Strength, pli**
		75°F	**160°F**	**180°F**	**75°F**
PAA with BR 127 Primer	ET-PP	4651	4282	3728	23.0
	ET-V	4535	3648	3200	24.2
	AT-PP	5026	4221	3800	36.3
	AT-V	4656	2740	2682	32.0
NPSG	ET-PP	3812	2944[m]	3002[m]	18.9
	ET-V	3282	2758	2560[m]	13.4
	AT-PP	3506	2184[m]	2271[m]	26.3[m]
	AT-V	3370	1950[m]	2079[m]	27.2
Scuff-sand / solvent wipe	ET-V	2663[m]	2407[m]	2439[m]	3.8[i]

Notes: [m] mixed failure mode (areas of cohesive and interfacial failure within specimen)
[i] interfacial failure at adhesive-aluminum interface

Magnobond 6398 follow-on wedge test results are provided in Table 25. The PAA/BR 127 and NPSG specimens failed cohesively within the adhesive while the scuff-sand/solvent wipe specimens failed at the adhesive-aluminum interface. Since initial crack lengths observed in the Magnobond 6398 specimens were similar to those of EA 9320NA wedge test specimens, failure mode results indicate Magnobond 6398 performs better in the wedge test than EA 9320NA. Magnobond 6398 NPSG wedge test results were considerably better than those achieved with Magnobond 6392-2. This difference is likely due to the difference in bondline control. Polyester scrim cloth was used to control the bondline thickness for Magnobond 6398, but scrim cloth was not used with Magnobond 6392-2 since it is manufactured with glass spacer beads. Cohesive failure modes are more easily obtained in the wedge test when using polyester scrim cloth versus glass beads (see Section 4.1). The reason for this is unknown.

Table 25. Magnobond 6398 Follow-On Wedge Test Results (120°F and 95-100% RH)

Surface Preparation	Cure Cycle	Initial Crack, in	Cumulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA with BR 127 Primer	ET-PP	1.78	0.03	0.03	0.05	0.06	0.07	0.07	100%
	ET-V	1.76	0.00	0.00	0.01	0.02	0.04	0.05	100%
	AT-PP	1.71	0.01	0.01	0.11	0.11	0.11	0.12	100%
	AT-V	1.79	0.06	0.06	0.06	0.13	0.13	0.13	100%
NPSG	ET-PP	1.78	0.02	0.05	0.10	0.10	0.12	0.14	98%
	ET-V	1.76	0.02	0.03	0.09	0.14	0.14	0.14	100%
	AT-PP	1.68	0.06	0.12	0.19	0.21	0.23	0.24	96%
	AT-V	1.80	0.00	0.03	0.15	0.17	0.18	0.18	93%
Scuff-sand / solvent wipe	ET-V	2.33	0.68	0.68	0.71	0.74	0.74	0.76	0%

5 Discussion

In order to compare the relative performance of each paste adhesive, the average failure mode of the tests from Section 4.2 was determined for each adhesive/surface preparation combination and plotted in Figure 1. Obviously, PAA/BR 127 provided the best overall performance for all adhesives, yielding nearly 100% cohesive failures. In addition, scuff-sand/solvent wipe provided the worst performance for the adhesives. Use of the NPSG surface preparation produced results somewhere between those observed for the other two processes, depending on the adhesive. The goal of this project was to identify candidate EA 9320NA replacement adhesives that provide similar properties (mechanical strengths), better working life, and good environmental durability with NPSG surface preparation. Using Figure 1 as a guide, all evaluated adhesives performed better than EA 9320NA when used with NPSG. EA 9360 appears to provide the best mix of properties and provides the best mix of properties with NPSG, including environmental durability, while still offering an ambient cure capability. EA 9380 also provided very good properties with NPSG, but it is only capable of elevated-temperature cure. EA 9377 provided excellent wedge test results with NPSG, but this adhesive offered reduced peel strengths and toughness. However, it would appear to be an excellent candidate for use in liquid shim applications with NPSG. Magnobond 6392-2 and 6398 outperformed EA 9320NA but did not match the combination of properties provided by EA 9360 and EA 9380.

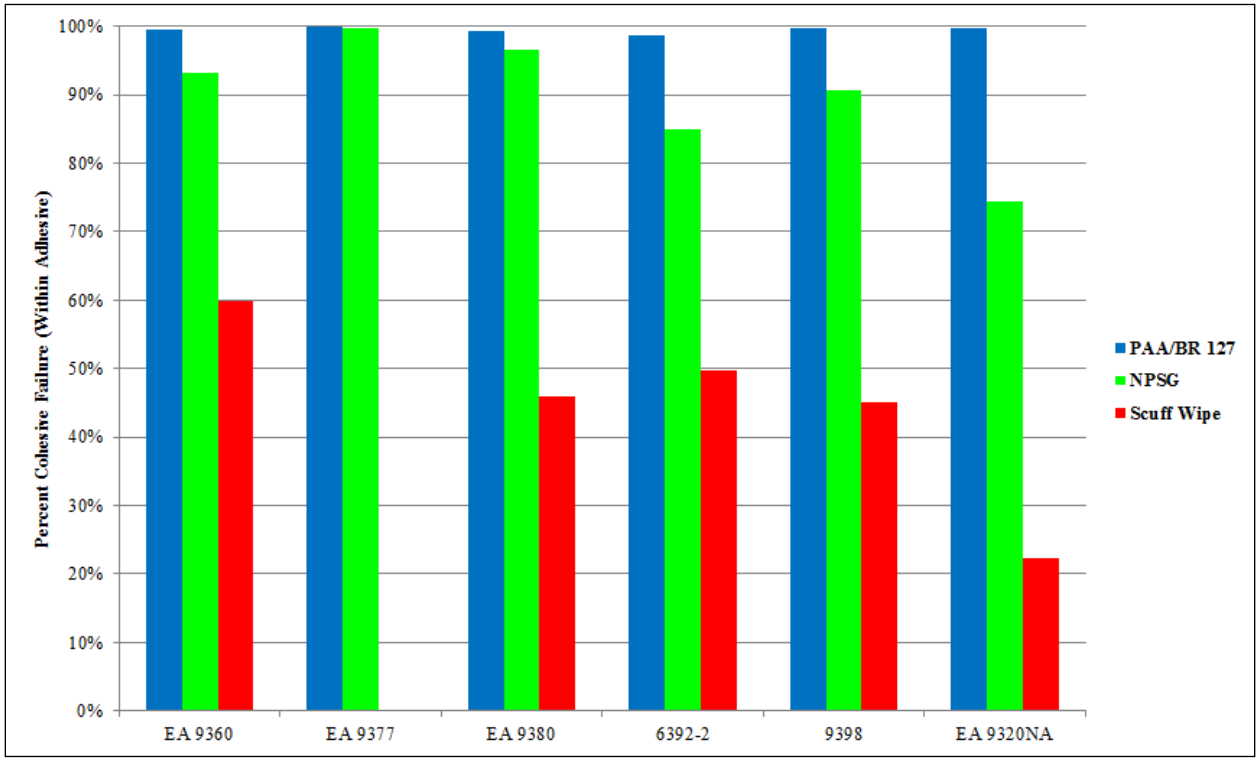

Figure 1. Comparison of Average Failure Modes from Follow-On Testing

6 Conclusions

Several adhesives were screened as alternatives to EA 9320NA for repair bonding applications that are not safety-of-flight critical. Several adhesives were removed from consideration during screening since they did not exhibit acceptable results with NPSG prebond surface preparation or did not demonstrate adequate material properties. Those adhesives included Magnobond 95, Magnobond 6168-1, Magnobond 6448, and Magnobond 6301. Screening wedge test results showed these materials exhibited excessive initial crack lengths and/or poor failure modes after 28-day exposures to 120°F and 95-100% RH.

Several adhesives produced favorable screening results and were further evaluated via lap shear, floating roller peel, and wedge testing. Results indicated multiple adhesives were viable alternatives to EA 9320NA, offering improved working life, higher strength at elevated temperature, improved peel strength, and better environmental durability when used with NPSG. Based on data generated in this project, EA 9360 proved to be the best alternative. EA 9380 also appeared to be a good alternative for applications limited to elevated-temperature curing. EA 9377 demonstrated compatibility with NPSG but offered lower toughness and peel strengths. This material could be considered for liquid shim applications in conjunction with NPSG. Magnobond 6398 and 6392-2 both offered improved environmental durability with NPSG as compared to EA 9320NA, but these adhesives did not consistently provide optimal failure modes in the wedge test. Magnobond 6398 and 6392-2 also exhibited lower peel strengths than EA 9320NA.

As with any material selection, the application of interest and its specific requirements must be considered. However, applications currently using EA 9320NA with NPSG should consider using EA 9360 to increase working life, improve evaluated-temperature strength, and increase bond environmental durability.

7 References

[1] TO 1C-5A-3, "Structural Repair Instructions, USAF Series, C-5A and C-5B Aircraft," Change 17, Section 11-55, 1 July 2008.

[2] D.B. McCray, "The Evaluation of Ambient-Temperature Processes for Repair Bonding of Aluminum Alloys," AFRL-ML-WP-TR-2002-4043, January 2002.

[3] J.W. Fiebig, J.J. Mazza, & D.B. McCray, "An ALC Consideration of Simple Sol-Gel Surface Preparations for Improved Durability of Field and Depot-Level Bonded Repairs," Proceedings of the 6th Joint FAA/DOD/NASA Conference on Aging Aircraft, Session 7B, San Francisco, CA, 16-19 September 2002.

[4] ASTM D3762-03(2010), Standard Test Method for Adhesive-Bonded Structure Durability of Aluminum (Wedge Test), ASTM International, 2010.

[5] ASTM D3933-98(2010), Standard Guide for Preparation of Aluminum Surfaces for Structural Adhesives Bonding (Phosphoric Acid Anodizing), ASTM International, 2010.

[6] ASTM D1002-10, Standard Test Method for Apparent Shear Strength of Single-Lap Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal), ASTM International, 2010.

[7] ASTM D3167-10, Standard Test Method for Floating Roller Peel Resistance of Adhesives, ASTM International, 2010.

Appendix A

Screening Wedge Test Individual Specimen Results

Table A-1. EA 9320NA Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Shouse	1	0.00	0.21	0.21	0.26	0.26	0.26	80%
		2	0.00	0.10	0.10	0.21	0.21	0.25	95%
		3	0.00	0.06	0.12	0.17	0.17	0.17	93%
		4	0.00	0.05	0.05	0.05	0.05	0.05	98%
		5	0.00	0.05	0.05	0.09	0.09	0.09	95%
		Average	***0.00***	***0.09***	***0.11***	***0.16***	***0.16***	***0.16***	***92%***
	Ripberger	1	0.00	0.10	0.21	0.21	0.21	0.21	75%
		2	0.10	0.14	0.17	0.17	0.17	0.21	70%
		3	0.00	0.00	0.00	0.02	0.02	0.02	95%
		4	0.12	0.12	0.16	0.16	0.16	0.17	50%
		5	0.00	0.09	0.12	0.12	0.12	0.19	92%
		Average	***0.04***	***0.09***	***0.13***	***0.14***	***0.14***	***0.16***	***76%***
	Smith	1	0.13	0.13	0.20	0.20	0.20	0.25	90%
		2	0.10	0.22	0.22	0.22	0.22	0.22	100%
		3	0.16	0.16	0.16	0.16	0.16	0.16	100%
		4	0.00	0.00	0.00	0.11	0.20	0.20	100%
		5	0.00	0.00	0.14	0.14	0.14	0.20	90%
		Average	***0.08***	***0.10***	***0.14***	***0.17***	***0.18***	***0.21***	***96%***
Glass Beads	Shouse	1	0.17	0.17	0.30	0.42	0.45	0.45	7%
		2	0.13	0.28	0.34	0.50	0.50	0.50	20%
		3	0.16	0.23	0.31	0.40	0.44	0.44	30%
		4	0.16	0.31	0.42	0.48	0.48	0.48	25%
		5	0.35	0.45	0.60	0.65	0.65	0.65	0%
		Average	***0.19***	***0.29***	***0.39***	***0.49***	***0.50***	***0.50***	***16%***
	Ripberger	1	0.13	0.16	0.22	0.24	0.29	0.35	50%
		2	0.04	0.12	0.23	0.26	0.26	0.26	0%
		3	0.06	0.08	0.11	0.15	0.19	0.19	5%
		4	0.10	0.17	0.17	0.24	0.24	0.24	50%
		5	0.00	0.00	0.11	0.15	0.19	0.19	55%
		Average	***0.07***	***0.11***	***0.17***	***0.21***	***0.23***	***0.25***	***32%***
	Smith	1	0.19	0.19	0.27	0.27	0.44	0.44	0%
		2	0.13	0.13	0.28	0.28	0.36	0.36	0%
		3	0.15	0.21	0.27	0.27	0.31	0.38	0%
		4	0.12	0.19	0.24	0.31	0.36	0.36	0%
		5	0.20	0.25	0.25	0.32	0.40	0.40	0%
		Average	***0.16***	***0.19***	***0.26***	***0.29***	***0.37***	***0.39***	***0%***

Table A-2. EA 9360 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Shouse	1	0.00	0.05	0.10	0.13	0.13	0.18	98%
		2	0.00	0.05	0.09	0.09	0.09	0.07	99%
		3	0.31	0.62	0.99	0.99	0.99	0.99	100%
		4	0.04	0.09	0.22	0.28	0.33	0.37	100%
		5	0.00	0.04	0.04	0.04	0.04	0.12	98%
		Average	***0.07***	***0.17***	***0.29***	***0.31***	***0.32***	***0.35***	***99%***
	Ripberger	1	0.00	0.04	0.04	0.13	0.13	0.13	98%
		2	0.00	0.04	0.05	0.05	0.05	0.09	100%
		3	0.00	0.00	0.00	0.02	0.02	0.03	99%
		4	0.00	0.03	0.05	0.07	0.07	0.09	100%
		5	0.00	0.03	0.03	0.03	0.03	0.03	98%
		Average	***0.00***	***0.03***	***0.03***	***0.06***	***0.06***	***0.07***	***99%***
	Smith	1	0.00	0.00	0.08	0.08	0.15	0.15	60%
		2	0.00	0.06	0.26	0.26	0.26	0.26	20%
		3	0.09	0.09	0.09	0.09	0.09	0.09	80%
		4	0.00	0.00	0.00	0.17	0.17	0.17	95%
		5	0.00	0.00	0.00	0.00	0.00	0.11	100%
		Average	***0.02***	***0.03***	***0.09***	***0.12***	***0.13***	***0.16***	***71%***
Glass Beads	Shouse	1	0.13	0.15	0.24	0.26	0.26	0.26	30%
		2	0.00	0.00	0.04	0.04	0.04	0.04	95%
		3	0.00	0.26	0.29	0.31	0.35	0.35	7%
		4	0.00	0.00	0.10	0.12	0.12	0.12	50%
		5	0.00	0.00	0.00	0.02	0.02	0.02	97%
		Average	***0.03***	***0.08***	***0.13***	***0.15***	***0.16***	***0.16***	***56%***
	Ripberger	1	0.00	0.00	0.02	0.03	0.03	0.03	60%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	98%
		5	0.00	0.00	0.00	0.00	0.00	0.00	78%
		Average	***0.00***	***0.00***	***0.00***	***0.01***	***0.01***	***0.01***	***87%***
	Smith	1	0.00	0.00	0.00	0.00	0.00	0.00	90%
		2	0.00	0.00	0.00	0.00	0.00	0.07	90%
		3	0.00	0.00	0.00	0.08	0.08	0.08	95%
		4	0.00	0.00	0.00	0.00	0.04	0.04	95%
		5	0.00	0.00	0.00	0.05	0.05	0.05	20%
		Average	***0.00***	***0.00***	***0.00***	***0.03***	***0.03***	***0.05***	***78%***

Table A-3. EA 9377 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Shouse	1	0.10	0.17	0.25	0.30	0.30	0.33	100%
		2	0.10	0.15	0.18	0.18	0.18	0.20	100%
		3	0.21	0.23	0.49	0.61	0.61	0.66	100%
		4	0.22	0.23	0.33	0.33	0.33	0.37	100%
		5	0.15	0.21	0.29	0.33	0.33	0.37	100%
		Average	***0.16***	***0.20***	***0.31***	***0.35***	***0.35***	***0.39***	***100%***
	Ripberger	1	0.09	0.18	0.18	0.22	0.22	0.23	99%
		2	0.00	0.08	0.08	0.08	0.08	0.08	100%
		3	0.29	0.30	0.30	0.32	0.32	0.33	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.04	0.04	0.08	0.08	0.09	100%
		Average	***0.08***	***0.12***	***0.12***	***0.14***	***0.14***	***0.15***	***100%***
	Smith	1	0.00	0.00	0.09	0.09	0.09	0.09	100%
		2	0.07	0.07	0.07	0.07	0.07	0.07	100%
		3	0.07	0.07	0.07	0.07	0.07	0.07	100%
		4	0.00	0.00	0.00	0.00	0.06	0.06	100%
		5	0.00	0.07	0.07	0.07	0.07	0.07	100%
		Average	***0.03***	***0.04***	***0.06***	***0.06***	***0.07***	***0.07***	***100%***
Glass Beads	Shouse	1	0.17	0.23	0.23	0.23	0.23	0.23	100%
		2	0.14	0.19	0.19	0.22	0.22	0.22	100%
		3	0.43	0.43	0.47	0.51	0.53	0.53	100%
		4	0.51	0.56	0.60	0.60	0.67	0.67	95%
		5	0.29	0.36	0.43	0.46	0.49	0.49	100%
		Average	***0.31***	***0.35***	***0.38***	***0.40***	***0.43***	***0.43***	***99%***
	Ripberger	1	0.10	0.12	0.17	0.17	0.17	0.17	99%
		2	0.13	0.18	0.20	0.28	0.28	0.28	99%
		3	0.13	0.13	0.15	0.20	0.20	0.20	100%
		4	0.22	0.24	0.26	0.26	0.33	0.38	100%
		5	0.17	0.22	0.22	0.24	0.24	0.24	100%
		Average	***0.15***	***0.18***	***0.20***	***0.23***	***0.24***	***0.25***	***100%***
	Smith	1	0.00	0.00	0.07	0.07	0.14	0.14	100%
		2	0.00	0.00	0.08	0.08	0.08	0.08	100%
		3	0.00	0.08	0.08	0.08	0.08	0.08	100%
		4	0.00	0.00	0.00	0.00	0.06	0.06	100%
		5	0.12	0.12	0.12	0.19	0.19	0.19	100%
		Average	***0.02***	***0.04***	***0.07***	***0.08***	***0.11***	***0.11***	***100%***

Table A-4. EA 9380 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Shouse	1	0.00	0.00	0.03	0.06	0.06	0.06	99%
		2	0.00	0.03	0.03	0.03	0.06	0.06	99%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.00***	***0.01***	***0.01***	***0.02***	***0.02***	***0.02***	***100%***
	Ripberger	1	0.00	0.03	0.03	0.03	0.03	0.03	99%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.00	0.05	0.05	0.05	0.05	0.09	99%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.01	0.01	0.01	0.01	100%
		Average	***0.00***	***0.02***	***0.02***	***0.02***	***0.02***	***0.03***	***100%***
	Smith	1	0.06	0.06	0.06	0.06	0.06	0.06	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.00	0.00	0.00	0.00	0.08	0.08	100%
		4	0.00	0.00	0.00	0.06	0.06	0.06	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.01***	***0.01***	***0.01***	***0.02***	***0.04***	***0.04***	***100%***
Glass Beads	Shouse	1	0.00	0.07	0.07	0.07	0.07	0.07	100%
		2	0.00	0.06	0.12	0.12	0.12	0.12	95%
		3	0.00	0.00	0.05	0.05	0.05	0.05	100%
		4	0.00	0.00	0.04	0.04	0.04	0.04	100%
		5	0.00	0.05	0.05	0.05	0.05	0.05	100%
		Average	***0.00***	***0.04***	***0.07***	***0.07***	***0.07***	***0.07***	***99%***
	Ripberger	1	0.00	0.08	0.12	0.16	0.16	0.16	100%
		2	0.00	0.00	0.03	0.03	0.03	0.06	100%
		3	0.00	0.00	0.00	0.06	0.06	0.06	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.04	0.04	0.08	0.08	0.08	100%
		Average	***0.00***	***0.02***	***0.04***	***0.07***	***0.07***	***0.07***	***100%***
	Smith	1	0.00	0.00	0.00	0.00	0.00	0.00	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.06	0.06	0.06	0.06	0.06	0.06	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.01***	***0.01***	***0.01***	***0.01***	***0.01***	***0.01***	***100%***

Table A-5. Magnobond 95 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Glass Beads	Shouse	1	0.00	0.02	0.02	0.05	0.05	0.05	100%
		2	0.00	0.00	0.01	0.01	0.01	0.01	99%
		3	0.07	0.07	0.08	0.08	0.08	0.08	99%
		4	0.03	0.03	0.03	0.05	0.05	0.05	99%
		5	0.06	0.06	0.07	0.07	0.07	0.07	99%
		Average	***0.03***	***0.04***	***0.04***	***0.05***	***0.05***	***0.05***	***99%***
	Ripberger	1	0.00	0.02	0.02	0.05	0.05	0.05	100%
		2	0.00	0.00	0.01	0.03	0.03	0.03	100%
		3	0.03	0.03	0.03	0.03	0.07	0.07	99%
		4	0.02	0.02	0.03	0.03	0.03	0.30	99%
		5	0.02	0.02	0.02	0.06	0.06	0.06	100%
		Average	***0.01***	***0.02***	***0.02***	***0.04***	***0.05***	***0.10***	***100%***

Table A-6. Magnobond 6168-1 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Glass Beads	Shouse	1	0.00	0.02	0.10	0.10	0.18	0.18	0%
		2	0.51	0.54	0.54	0.54	0.54	0.54	8%
		3	0.00	0.00	0.00	0.03	0.03	0.12	50%
		4	0.00	0.00	0.00	0.00	0.00	0.00	20%
		5	0.04	0.04	0.04	0.04	0.13	0.18	0%
		Average	***0.11***	***0.12***	***0.14***	***0.14***	***0.18***	***0.20***	***16%***
	Ripberger	1	0.09	0.09	0.36	0.36	0.36	0.36	0%
		2	0.00	0.00	0.00	0.05	0.05	0.05	0%
		3	0.57	0.59	0.66	0.66	0.66	0.66	2%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.10	0.14	0.33	0.37	0.42	0.42	0%
		Average	***0.15***	***0.16***	***0.27***	***0.29***	***0.30***	***0.30***	***20%***
	Smith	1	0.00	0.00	0.00	0.08	0.08	0.23	0%
		2	0.00	0.00	0.00	0.00	0.16	0.16	0%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.06	0.06	0.06	0.12	0%
		5	0.08	0.08	0.25	0.32	0.32	0.38	0%
		Average	***0.02***	***0.02***	***0.06***	***0.09***	***0.12***	***0.18***	***20%***

Table A-7. Magnobond 6392-2 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Glass Beads	Shouse	1	0.00	0.06	0.08	0.08	0.13	0.16	100%
		2	0.00	0.03	0.15	0.15	0.15	0.17	100%
		3	0.05	0.15	0.23	0.24	0.24	0.24	100%
		4	0.00	0.03	0.10	0.14	0.14	0.14	90%
		5	0.00	0.03	0.06	0.11	0.11	0.12	80%
		Average	***0.01***	***0.06***	***0.12***	***0.14***	***0.15***	***0.17***	***94%***
	Ripberger	1	0.00	0.07	0.12	0.12	0.12	0.12	100%
		2	0.00	0.00	0.00	0.01	0.01	0.01	100%
		3	0.00	0.00	0.00	0.01	0.01	0.01	100%
		4	0.00	0.09	0.09	0.09	0.09	0.11	100%
		5	0.00	0.07	0.07	0.13	0.13	0.13	100%
		Average	***0.00***	***0.05***	***0.06***	***0.07***	***0.07***	***0.08***	***100%***
	Smith	1	0.06	0.06	0.08	0.08	0.08	0.18	90%
		2	0.05	0.05	0.05	0.05	0.11	0.11	90%
		3	0.00	0.05	0.05	0.05	0.10	0.10	95%
		4	0.00	0.05	0.05	0.05	0.05	0.05	90%
		5	0.06	0.06	0.06	0.12	0.12	0.12	95%
		Average	***0.03***	***0.05***	***0.06***	***0.07***	***0.09***	***0.11***	***92%***

Table A-8. Magnobond 6398 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode,
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	% coh.
Scrim	Shouse	1	0.03	0.16	0.16	0.21	0.21	0.21	90%
		2	0.08	0.12	0.12	0.12	0.12	0.20	100%
		3	0.06	0.08	0.17	0.18	0.18	0.23	80%
		4	0.00	0.00	0.00	0.00	0.00	0.00	90%
		5	0.06	0.09	0.16	0.18	0.18	0.18	100%
		Average	***0.05***	***0.09***	***0.12***	***0.14***	***0.14***	***0.16***	***92%***
	Ripberger	1	0.06	0.06	0.17	0.17	0.17	0.17	99%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.03	0.07	0.07	0.07	0.07	100%
		Average	***0.01***	***0.02***	***0.05***	***0.05***	***0.05***	***0.05***	***100%***
	Smith	1	0.00	0.00	0.00	0.15	0.15	0.15	100%
		2	0.00	0.00	0.15	0.15	0.20	0.20	100%
		3	0.00	0.00	0.05	0.05	0.14	0.14	100%
		4	0.00	0.00	0.10	0.10	0.10	0.10	100%
		5	0.00	0.00	0.00	0.00	0.05	0.05	100%
		Average	***0.00***	***0.00***	***0.06***	***0.09***	***0.13***	***0.13***	***100%***
Glass Beads	Shouse	1	0.03	0.04	0.15	0.15	0.15	0.15	95%
		2	0.00	0.00	0.04	0.06	0.06	0.06	100%
		3	0.09	0.09	0.10	0.10	0.10	0.10	94%
		4	0.00	0.06	0.09	0.09	0.09	0.09	98%
		5	0.07	0.07	0.14	0.19	0.19	0.19	99%
		Average	***0.04***	***0.05***	***0.10***	***0.12***	***0.12***	***0.12***	***97%***
	Ripberger	1	0.04	0.04	0.18	0.21	0.21	0.25	100%
		2	0.01	0.02	0.06	0.15	0.15	0.18	97%
		3	0.04	0.08	0.12	0.21	0.21	0.21	78%
		4	0.17	0.22	0.75	0.83	0.97	0.97	58%
		5	0.00	0.00	0.00	0.09	0.09	0.09	99%
		Average	***0.05***	***0.07***	***0.22***	***0.30***	***0.33***	***0.34***	***86%***
	Smith	1	0.00	0.00	0.05	0.14	0.14	0.14	100%
		2	0.00	0.00	0.00	0.07	0.07	0.07	60%
		3	0.00	0.00	0.07	0.07	0.07	0.07	80%
		4	0.00	0.00	0.05	0.05	0.05	0.11	70%
		5	0.00	0.00	0.00	0.10	0.10	0.10	95%
		Average	***0.00***	***0.00***	***0.03***	***0.09***	***0.09***	***0.10***	***81%***

Table A-9. Magnobond 6448 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Shouse	1	0.00	0.04	0.07	0.12	0.12	0.12	97%
		2	0.06	0.06	0.13	0.13	0.13	0.13	100%
		3	0.00	0.00	0.00	0.05	0.05	0.05	95%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.06	0.06	0.12	0.12	0.12	99%
		Average	***0.01***	***0.03***	***0.05***	***0.08***	***0.08***	***0.08***	***98%***
	Ripberger	1	0.00	0.06	0.09	0.15	0.15	0.17	96%
		2	0.00	0.02	0.02	0.09	0.09	0.11	99%
		3	0.00	0.01	0.08	0.08	0.08	0.11	99%
		4	0.00	0.02	0.06	0.10	0.10	0.10	100%
		5	0.00	0.00	0.05	0.05	0.05	0.06	100%
		Average	***0.00***	***0.02***	***0.06***	***0.09***	***0.09***	***0.11***	***99%***
	Smith	1	0.00	0.00	0.13	0.13	0.18	0.18	100%
		2	0.00	0.00	0.10	0.10	0.14	0.14	100%
		3	0.00	0.00	0.16	0.16	0.23	0.23	100%
		4	0.00	0.00	0.00	0.16	0.16	0.16	100%
		5	0.00	0.05	0.11	0.11	0.11	0.11	100%
		Average	***0.00***	***0.01***	***0.10***	***0.13***	***0.16***	***0.16***	***100%***
Glass Beads	Shouse	1	0.02	0.12	0.21	0.22	0.22	0.22	50%
		2	0.00	0.00	0.00	0.04	0.04	0.04	50%
		3	0.04	0.10	0.22	0.39	0.45	0.45	60%
		4	0.79	0.79	0.82	0.82	0.82	0.82	25%
		5	0.00	0.19	0.23	0.23	0.23	0.23	20%
		Average	***0.17***	***0.24***	***0.30***	***0.34***	***0.35***	***0.35***	***41%***
	Ripberger	1	0.02	0.06	0.10	0.10	0.10	0.10	70%
		2	0.61	0.70	0.81	0.81	0.81	0.81	20%
		3	0.15	0.26	0.43	0.50	0.50	0.50	25%
		4	0.03	0.14	0.21	0.31	0.31	0.31	93%
		5	0.03	0.11	0.19	0.19	0.19	0.29	45%
		Average	***0.17***	***0.25***	***0.35***	***0.38***	***0.38***	***0.40***	***51%***
	Smith	1	0.00	0.00	0.06	0.06	0.13	0.13	90%
		2	0.00	0.00	0.00	0.09	0.09	0.09	90%
		3	0.00	0.00	0.00	0.00	0.00	0.06	100%
		4	0.00	0.00	0.00	0.00	0.06	0.06	100%
		5	0.00	0.00	0.00	0.00	0.11	0.11	100%
		Average	***0.00***	***0.00***	***0.01***	***0.03***	***0.08***	***0.09***	***96%***

Table A-10. Magnobond 6301 Individual Specimen Wedge Test Results

Bondline Control	Fabricator	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
Scrim	Shouse	1	0.00	0.01	0.06	0.06	0.06	0.09	98%
		2	0.00	0.00	0.00	0.01	0.01	0.08	97%
		3	0.00	0.31	0.31	0.31	0.31	0.31	100%
		4	0.00	0.04	0.15	0.19	0.23	0.23	97%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.00***	***0.07***	***0.10***	***0.11***	***0.12***	***0.14***	***98%***
	Ripberger	1	0.00	0.22	0.25	0.25	0.29	0.29	95%
		2	0.23	0.23	0.35	0.40	0.40	0.40	95%
		3	0.00	0.00	0.03	0.03	0.03	0.05	100%
		4	0.00	0.06	0.09	0.09	0.09	0.11	95%
		5	0.00	0.00	0.00	0.00	0.00	0.00	98%
		Average	***0.05***	***0.10***	***0.14***	***0.15***	***0.16***	***0.17***	***97%***
	Smith	1	0.00	0.00	0.00	0.00	0.00	0.11	100%
		2	0.31	0.31	0.31	0.31	0.31	0.31	100%
		3	0.48	0.48	0.48	0.48	0.48	0.48	95%
		4	0.00	0.00	0.12	0.12	0.12	0.12	100%
		5	0.00	0.00	0.10	0.10	0.21	0.21	100%
		Average	***0.16***	***0.16***	***0.20***	***0.20***	***0.22***	***0.25***	***99%***
Glass Beads	Shouse	1	0.09	0.09	0.46	0.68	0.93	0.93	0%
		2	0.30	0.36	0.54	0.64	0.64	0.70	0%
		3	0.75	0.81	0.83	0.91	0.91	0.98	0%
		4	0.56	0.56	0.64	0.67	0.67	0.74	0%
		5	0.00	0.00	0.00	0.05	0.05	0.05	0%
		Average	***0.34***	***0.36***	***0.49***	***0.59***	***0.64***	***0.68***	***0%***
	Ripberger	1	0.00	0.02	0.02	0.02	0.02	0.05	0%
		2	0.00	0.00	0.08	0.08	0.08	0.08	0%
		3	0.42	0.46	0.55	0.60	0.60	0.60	0%
		4	0.00	0.03	0.03	0.03	0.03	0.03	3%
		5	0.60	0.60	0.69	0.69	0.77	0.77	20%
		Average	***0.20***	***0.22***	***0.27***	***0.28***	***0.30***	***0.31***	***5%***
	Smith	1	0.22	0.22	0.22	0.22	0.22	0.30	0%
		2	0.40	0.40	0.46	0.46	0.46	0.46	0%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.84	0.93	0.93	0.93	0.93	1.00	0%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.29***	***0.31***	***0.32***	***0.32***	***0.32***	***0.35***	***40%***

Appendix B

Follow-On Adhesive Testing Individual Specimen Test Results

Table B-1. EA 9320NA Lap Shear Test Results

Surface Preparation	Cure Cycle	Test Temperature	Lap Shear Strength (psi)						Failure Mode (% Coh)
			1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	75°F	5912	5942	6010	5877	5435	***5835***	100%
		160°F	3787	3522	3595	3486	3486	***3575***	100%
		180°F	2865	2656	2430	2370	2228	***2510***	100%
	ET-V	75°F	5211	5032	5244	5006	4964	***5091***	100%
		160°F	3052	2938	2970	2934	2918	***2962***	100%
		180°F	1978	1958	1978	1858	1976	***1950***	100%
	AT-PP	75°F	5040	5396	5267	5254	5090	***5209***	100%
		160°F	2519	2483	2334	2469	2229	***2407***	100%
		180°F	2053	1410	1524	1751	1539	***1655***	95%
	AT-V	75°F	4666	4757	4675	4699	4746	***4709***	100%
		160°F	1974	1867	1817	1834	1902	***1879***	100%
		180°F	1450	1600	1302	1289	1527	***1434***	100%
NPSG	ET-PP	75°F	4181	4221	4501	4212	4074	***4238***	95%
		160°F	1780	1885	1690	1817	1793	***1793***	50%
		180°F	714	739	720	770	764	***741***	0%
	ET-V	75°F	3436	3747	3794	3761	3758	***3699***	100%
		160°F	310	408	370	337	418	***369***	100%
		180°F	186	187	176	249	239	***207***	100%
	AT-PP	75°F	4149	4096	3957	3888	4054	***4029***	100%
		160°F	1480	1682	1541	1376	1440	***1504***	88%
		180°F	779	814	756	739	810	***780***	70%
	AT-V	75°F	3609	3446	3224	3310	3150	***3348***	100%
		160°F	1448	1447	1486	1303	1263	***1389***	91%
		180°F	472	501	733	633	637	***595***	52%
Scuff-sand/solvent wipe	ET-V	75°F	3920	3833	3368	3674	3378	***3635***	91%
		160°F	1480	1535	1515	1290	1333	***1431***	20%
		180°F	661	507	425	545	576	***543***	0%

Table B-2. EA 9320NA Floating Roller Peel Test Results

Surface Preparation	Cure Cycle	75°F Peel Strength (pli)						Failure Mode (% Coh)
		1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	39.8	41.5	40.5	36.3	34.1	***38.4***	100%
	ET-V	40.2	41.0	40.0	38.7	37.2	***39.4***	100%
	AT-PP	36.9	38.8	39.5	38.2	33.1	***37.3***	100%
	AT-V	36.7	38.2	38.1	36.8	36.5	***37.3***	100%
NPSG	ET-PP	28.8	11.9	23.6	28.8	29.4	***24.5***	50%
	ET-V	21.6	25.4	25.3	22.8	14.4	***21.9***	100%
	AT-PP	30.1	33.8	33.0	32.4	28.7	***31.6***	88%
	AT-V	31.3	32.5	34.1	34.2	31.9	***32.8***	92%
Scuff-sand / solvent wipe	ET-V	3.8	3.5	3.6	3.6	4.1	***3.7***	0%

Table B-3. EA 9320NA Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA/BR 127	ET-PP	1	0.11	0.11	0.17	0.17	0.17	0.17	100%
		2	0.00	0.00	0.11	0.17	0.17	0.17	100%
		3	0.00	0.00	0.09	0.09	0.09	0.09	100%
		4	0.00	0.07	0.07	0.07	0.07	0.14	100%
		5	0.00	0.07	0.07	0.07	0.07	0.07	100%
		Average	***0.02***	***0.05***	***0.10***	***0.11***	***0.11***	***0.13***	***100%***
	ET-V	1	0.00	0.00	0.00	0.10	0.10	0.10	100%
		2	0.07	0.07	0.15	0.15	0.15	0.15	100%
		3	0.09	0.09	0.14	0.14	0.14	0.14	100%
		4	0.10	0.10	0.16	0.22	0.22	0.22	100%
		5	0.05	0.05	0.16	0.16	0.16	0.16	100%
		Average	***0.06***	***0.06***	***0.12***	***0.15***	***0.15***	***0.15***	***100%***
	AT-PP	1	0.30	0.30	0.30	0.30	0.30	0.30	100%
		2	0.68	0.68	0.68	0.68	0.68	0.68	100%
		3	0.50	0.50	0.50	0.50	0.50	0.50	100%
		4	0.46	0.46	0.46	0.46	0.46	0.46	100%
		5	0.15	0.15	0.15	0.15	0.15	0.15	100%
		Average	***0.42***	***0.42***	***0.42***	***0.42***	***0.42***	***0.42***	***100%***
	AT-V	1	0.07	0.07	0.07	0.07	0.07	0.07	100%
		2	0.00	0.00	0.06	0.06	0.06	0.06	100%
		3	0.11	0.11	0.11	0.11	0.11	0.11	100%
		4	0.09	0.09	0.09	0.09	0.09	0.09	100%
		5	0.08	0.08	0.08	0.08	0.08	0.17	100%
		Average	***0.07***	***0.07***	***0.08***	***0.08***	***0.08***	***0.10***	***100%***

Table B-3 (continued). EA 9320NA Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
NPSG	ET-PP	1	0.07	0.35	0.35	0.53	0.61	0.61	20%
		2	0.13	0.19	0.32	0.41	0.41	0.41	10%
		3	0.15	0.21	0.32	0.38	0.38	0.38	0%
		4	0.15	0.19	0.33	0.38	0.38	0.44	0%
		5	0.07	0.17	0.30	0.42	0.42	0.42	0%
		Average	***0.11***	***0.22***	***0.32***	***0.42***	***0.44***	***0.45***	***6%***
	ET-V	1	0.22	0.22	0.22	0.22	0.22	0.22	100%
		2	0.16	0.16	0.16	0.16	0.16	0.16	100%
		3	0.15	0.15	0.15	0.15	0.15	0.15	100%
		4	0.17	0.17	0.17	0.17	0.17	0.17	100%
		5	0.33	0.33	0.33	0.33	0.33	0.33	100%
		Average	***0.21***	***0.21***	***0.21***	***0.21***	***0.21***	***0.21***	***100%***
	AT-PP	1	0.12	0.18	0.33	0.44	0.44	0.49	20%
		2	0.14	0.18	0.26	0.37	0.37	0.37	20%
		3	0.20	0.24	0.30	0.42	0.42	0.42	20%
		4	0.18	0.23	0.23	0.32	0.37	0.37	20%
		5	0.18	0.18	0.31	0.31	0.41	0.41	20%
		Average	***0.16***	***0.20***	***0.29***	***0.37***	***0.40***	***0.41***	***20%***
	AT-V	1	0.16	0.23	0.28	0.28	0.28	0.28	80%
		2	0.12	0.19	0.19	0.29	0.29	0.29	80%
		3	0.10	0.10	0.10	0.10	0.10	0.10	90%
		4	0.07	0.20	0.28	0.28	0.28	0.28	80%
		5	0.08	0.08	0.16	0.26	0.26	0.26	90%
		Average	***0.11***	***0.16***	***0.20***	***0.24***	***0.24***	***0.24***	***84%***
Scuff-sand / solvent wipe	ET-V	1	1.11	1.11	1.18	1.27	1.27	1.27	0%
		2	0.84	0.84	0.84	0.84	0.84	0.84	0%
		3	0.93	0.93	0.93	0.93	0.93	0.93	0%
		4	0.83	0.83	0.83	0.91	0.91	0.91	0%
		5	0.57	0.57	0.57	0.63	0.63	0.63	0%
		Average	***0.86***	***0.86***	***0.87***	***0.92***	***0.92***	***0.92***	***0%***

Table B-4. EA 9360 Lap Shear Test Results

Surface Preparation	Cure Cycle	Test Temperature	Lap Shear Strength (psi)						Failure Mode (% Coh)
			1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	75°F	6096	4990	5111	5064	5058	***5264***	90%
		160°F	4298	4565	4171	4264	4568	***4373***	100%
		180°F	3975	3726	3501	3612	3909	***3745***	100%
	ET-V	75°F	6085	6265	5636	5580	5317	***5777***	100%
		160°F	4269	4229	4068	4128	3811	***4101***	100%
		180°F	3169	3398	3351	3392	3294	***3321***	100%
	AT-PP	75°F	5566	5404	4647	5082	4799	***5100***	100%
		160°F	3255	3144	3152	3142	3198	***3178***	100%
		180°F	3260	3340	3270	3170	2815	***3171***	100%
	AT-V	75°F	4831	5127	5184	4933	5142	***5043***	100%
		160°F	2885	2880	2828	3064	3034	***2938***	100%
		180°F	2486	2748	2846	3066	2807	***2791***	100%
NPSG	ET-PP	75°F	4549	4358	4528	4684	4679	***4560***	97%
		160°F	3388	3323	3260	3364	3391	***3345***	82%
		180°F	3030	2627	2964	3045	2710	***2875***	78%
	ET-V	75°F	4523	4218	4391	5083	4760	***4595***	100%
		160°F	3124	3270	3493	3074	3514	***3295***	96%
		180°F	2770	2576	2697	2562	2794	***2680***	93%
	AT-PP	75°F	4686	4306	3904	4159	4842	***4379***	95%
		160°F	2862	2815	2439	2590	2711	***2683***	89%
		180°F	2183	2445	2521	2343	2458	***2390***	77%
	AT-V	75°F	4384	4405	4014	4248	4405	***4291***	100%
		160°F	2523	2598	2781	2831	2956	***2738***	98%
		180°F	2171	2272	2103	2061	2416	***2205***	84%
Scuff-sand/solvent wipe	ET-V	75°F	3926	4112	4056	4082	4156	***4066***	100%
		160°F	3130	3157	2725	2948	3260	***3044***	82%
		180°F	2212	2560	2527	2383	2411	***2419***	70%

Table B-5. EA 9360 Floating Roller Peel Test Results

Surface Preparation	Cure Cycle	75°F Peel Strength (pli)						Failure Mode (% Coh)
		1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	31.7	36.4	38.3	35.2	36.5	***35.6***	100%
	ET-V	34.1	36.6	38.1	37.5	38.8	***37.0***	100%
	AT-PP	39.1	44.0	44.4	42.9	40.5	***42.2***	100%
	AT-V	41.7	44.9	46.4	47.2	45.6	***45.2***	100%
NPSG	ET-PP	32.5	32.3	32.2	32.4	32.8	***32.4***	95%
	ET-V	36.3	36.1	35.9	36.0	34.3	***35.7***	96%
	AT-PP	39.5	44.9	45.9	47.8	39.3	***43.5***	92%
	AT-V	46.8	48.6	48.1	46.8	43.8	***46.8***	95%
Scuff-sand / solvent wipe	ET-V	22.1	15.4	20.0	28.0	29.7	***23.0***	28%

Table B-6. EA 9360 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA/BR 127	ET-PP	1	0.00	0.00	0.11	0.11	0.11	0.11	100%
		2	0.00	0.00	0.00	0.06	0.06	0.06	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.10	0.10	0.10	0.10	100%
		Average	***0.00***	***0.00***	***0.04***	***0.05***	***0.05***	***0.05***	***100%***
	ET-V	1	0.00	0.00	0.00	0.00	0.00	0.00	100%
		2	0.00	0.00	0.05	0.05	0.05	0.05	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.08	0.08	0.08	0.08	100%
		Average	***0.00***	***0.00***	***0.03***	***0.03***	***0.03***	***0.03***	***100%***
	AT-PP	1	0.06	0.06	0.06	0.06	0.06	0.06	100%
		2	0.39	0.39	0.39	0.39	0.39	0.39	100%
		3	0.06	0.06	0.06	0.06	0.13	0.13	100%
		4	0.07	0.07	0.07	0.07	0.07	0.07	100%
		5	0.09	0.09	0.09	0.09	0.09	0.09	100%
		Average	***0.13***	***0.13***	***0.13***	***0.13***	***0.15***	***0.15***	***100%***
	AT-V	1	0.00	0.00	0.00	0.06	0.06	0.06	100%
		2	0.13	0.13	0.13	0.13	0.13	0.13	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.03***	***0.03***	***0.03***	***0.04***	***0.04***	***0.04***	***100%***

Table B-6 (continued). EA 9360 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
NPSG	ET-PP	1	0.06	0.06	0.13	0.13	0.13	0.13	100%
		2	0.00	0.11	0.11	0.11	0.11	0.11	100%
		3	0.00	0.07	0.07	0.07	0.07	0.07	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.01***	***0.05***	***0.06***	***0.06***	***0.06***	***0.06***	***100%***
	ET-V	1	0.00	0.00	0.13	0.13	0.13	0.13	100%
		2	0.00	0.00	0.00	0.06	0.06	0.06	100%
		3	0.00	0.00	0.00	0.07	0.07	0.07	100%
		4	0.00	0.00	0.00	0.06	0.06	0.06	100%
		5	0.00	0.00	0.00	0.07	0.07	0.07	100%
		Average	***0.00***	***0.00***	***0.03***	***0.08***	***0.08***	***0.08***	***100%***
	AT-PP	1	0.07	0.07	0.18	0.22	0.22	0.22	100%
		2	0.09	0.09	0.09	0.09	0.09	0.09	100%
		3	0.08	0.08	0.08	0.08	0.08	0.08	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.12	0.12	0.12	0.21	0.21	0.21	90%
		Average	***0.07***	***0.07***	***0.09***	***0.12***	***0.12***	***0.12***	***98%***
	AT-V	1	0.00	0.00	0.00	0.00	0.00	0.18	100%
		2	0.00	0.00	0.00	0.00	0.13	0.13	95%
		3	0.00	0.00	0.11	0.11	0.11	0.11	100%
		4	0.00	0.00	0.00	0.09	0.18	0.18	100%
		5	0.09	0.09	0.16	0.16	0.16	0.16	90%
		Average	***0.02***	***0.02***	***0.05***	***0.07***	***0.12***	***0.15***	***97%***
Scuff-sand / solvent wipe	ET-V	1	0.90	0.90	0.90	0.90	0.90	0.90	0%
		2	1.03	1.03	1.03	1.03	1.03	1.03	0%
		3	1.26	1.26	1.26	1.26	1.26	1.26	0%
		4	1.55	1.55	1.55	1.55	1.55	1.55	0%
		5	0.00	0.00	0.00	0.00	0.04	0.04	95%
		Average	***0.95***	***0.95***	***0.95***	***0.95***	***0.96***	***0.96***	***19%***

Table B-7. EA 9380 Lap Shear Test Results

Surface Preparation	Cure Cycle	Test Temperature	Lap Shear Strength (psi)						Failure Mode (% Coh)
			1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	75°F	6056	5962	4382	5546	5541	***5497***	96%
		160°F	4096	4254	3495	3504	3505	***3771***	98%
		180°F	3162	3089	3067	2844	3218	***3076***	100%
	ET-V	75°F	3972	4238	3886	4000	3699	***3959***	100%
		160°F	2680	2605	2719	2652	2607	***2653***	100%
		180°F	2466	2430	2346	2219	2217	***2336***	100%
NPSG	ET-PP	75°F	4040	4227	4071	4030	3947	***4063***	100%
		160°F	4044	3656	3372	3498	3626	***3639***	100%
		180°F	2815	2786	2802	3059	3119	***2916***	96%
	ET-V	75°F	3615	3922	3376	3798	3715	***3685***	100%
		160°F	2844	2755	2686	2384	2461	***2626***	100%
		180°F	2323	2344	2108	2122	1990	***2177***	100%
Scuff-sand/solvent wipe	ET-V	75°F	2180	2591	2397	2563	2933	***2533***	68%
		160°F	2328	2109	2359	2444	2359	***2320***	80%
		180°F	2188	1790	1901	2055	2004	***1988***	82%

Table B-8. EA 9380 Floating Roller Peel Test Results

Surface Preparation	Cure Cycle	75°F Peel Strength (pli)						Failure Mode (% Coh)
		1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	40.3	35.6	32.4	33.9	34.2	***35.3***	100%
	ET-V	36.3	39.9	42.0	37.1	29.1	***36.9***	100%
NPSG	ET-PP	11.9	10.9	13.4	11.9	21.3	***13.9***	90%
	ET-V	26.3	22.6	22.5	24.7	25.8	***24.4***	80%
Scuff-sand / solvent wipe	ET-V	3.4	3.7	3.6	4.0	3.3	***3.6***	0%

Table B-9. EA 9380 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA/BR 127	ET-PP	1	0.00	0.00	0.00	0.00	0.00	0.00	100%
		2	0.00	0.00	0.00	0.06	0.06	0.06	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.00***	***0.00***	***0.00***	***0.01***	***0.01***	***0.01***	***100%***
	ET-V	1	0.00	0.00	0.00	0.00	0.00	0.00	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***100%***
NPSG	ET-PP	1	0.00	0.00	0.00	0.00	0.00	0.00	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***100%***
	ET-V	1	0.00	0.00	0.00	0.07	0.07	0.07	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.04	0.04	0.04	0.04	100%
		5	0.00	0.00	0.06	0.12	0.12	0.12	100%
		Average	***0.00***	***0.00***	***0.02***	***0.05***	***0.05***	***0.05***	***100%***
Scuff-sand / solvent wipe	ET-V	1	1.30	1.65	1.65	1.65	1.84	1.84	0%
		2	1.03	1.24	1.24	1.24	1.24	1.24	0%
		3	0.86	1.36	1.36	1.36	1.36	1.36	0%
		4	1.06	1.29	1.48	1.48	1.48	1.48	0%
		5	0.56	1.16	1.16	1.16	1.16	1.16	0%
		Average	***0.96***	***1.34***	***1.38***	***1.38***	***1.42***	***1.42***	***0%***

Table B-10. EA 9377 Lap Shear Test Results

Surface Preparation	Cure Cycle	Test Temperature	Lap Shear Strength (psi)						Failure Mode (% Coh)
			1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	75°F	2480	2550	2447	2544	2503	***2505***	100%
		160°F	2303	2365	2443	2250	2016	***2275***	100%
		180°F	2275	2298	2289	2208	2322	***2278***	100%
	ET-V	75°F	2150	2136	2157	2150	2260	***2171***	100%
		160°F	2088	1826	1831	1721	1809	***1855***	100%
		180°F	1675	1731	1828	1887	1878	***1800***	100%
	AT-PP	75°F	2375	2577	2455	2461	2193	***2412***	100%
		160°F	1597	2238	1933	1601	1240	***1722***	100%
		180°F	1053	1167	1209	1323	1555	***1261***	100%
	AT-V	75°F	2678	2906	2584	2611	2658	***2687***	100%
		160°F	1602	1654	1924	1973	2274	***1885***	100%
		180°F	1862	2123	2361	2260	1807	***2083***	100%
NPSG	ET-PP	75°F	2371	2236	2462	2227	2388	***2337***	100%
		160°F	1939	1961	1887	1852	1948	***1917***	100%
		180°F	1688	1910	2051	2211	2103	***1993***	100%
	ET-V	75°F	2347	2255	2317	2191	2220	***2266***	100%
		160°F	1934	2139	2063	2037	2002	***2035***	100%
		180°F	1968	2030	2026	1847	1958	***1966***	100%
	AT-PP	75°F	2522	2439	2176	2264	2300	***2340***	100%
		160°F	1966	2254	2210	2045	2082	***2111***	100%
		180°F	1589	1967	1863	1880	1658	***1791***	96%
	AT-V	75°F	2535	2586	2606	2626	2558	***2582***	100%
		160°F	1962	2144	2016	1723	1711	***1911***	100%
		180°F	2215	2290	2107	2094	1865	***2114***	100%
Scuff-sand/solvent wipe	ET-V	75°F	679	727	905	644	746	***740***	0%
		160°F	533	580	617	685	715	***626***	0%
		180°F	594	527	441	392	516	***494***	0%

Table B-11. EA 9377 Floating Roller Peel Test Results

Surface Preparation	Cure Cycle	75°F Peel Strength (pli)						Failure Mode (% Coh)
		1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	3.5	3.5	3.4	3.5	4.3	***3.6***	100%
	ET-V	3.6	3.2	3.0	3.4	3.2	***3.3***	100%
	AT-PP	4.2	4.0	4.3	4.4	4.5	***4.3***	100%
	AT-V	4.2	3.8	3.8	3.6	3.8	***3.8***	100%
NPSG	ET-PP	5.4	4.1	3.9	3.9	3.8	***4.2***	100%
	ET-V	3.5	3.5	3.5	3.6	3.5	***3.5***	100%
	AT-PP	5.0	7.4	4.4	4.4	4.5	***5.1***	100%
	AT-V	4.5	4.3	4.6	5.0	3.4	***4.4***	100%
Scuff-sand / solvent wipe	ET-V	4.2	4.1	4.0	4.6	3.9	***4.2***	0%

Table B-12. EA 9377 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA/BR 127	ET-PP	1	0.00	0.00	0.06	0.06	0.06	0.06	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.15	0.24	0.24	0.24	0.28	0.28	100%
		4	0.15	0.15	0.15	0.15	0.15	0.15	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.06***	***0.08***	***0.09***	***0.09***	***0.10***	***0.10***	***100%***
	ET-V	1	0.00	0.00	0.00	0.00	0.00	0.00	100%
		2	0.08	0.08	0.08	0.08	0.08	0.08	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.07	0.07	0.07	0.07	0.15	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.02***	***0.03***	***0.03***	***0.03***	***0.03***	***0.05***	***100%***
	AT-PP	1	0.08	0.08	0.08	0.15	0.15	0.22	100%
		2	0.16	0.16	0.16	0.16	0.26	0.26	100%
		3	0.21	0.21	0.21	0.21	0.21	0.21	100%
		4	0.17	0.17	0.24	0.24	0.24	0.24	100%
		5	0.06	0.06	0.06	0.14	0.14	0.14	100%
		Average	***0.14***	***0.14***	***0.15***	***0.18***	***0.20***	***0.21***	***100%***
	AT-V	1	0.06	0.06	0.12	0.12	0.12	0.12	100%
		2	0.09	0.09	0.09	0.09	0.17	0.17	100%
		3	0.14	0.14	0.14	0.14	0.14	0.14	100%
		4	0.07	0.24	0.24	0.24	0.24	0.24	100%
		5	0.09	0.09	0.09	0.09	0.09	0.09	100%
		Average	***0.09***	***0.12***	***0.14***	***0.14***	***0.15***	***0.15***	***100%***

Table B-12 (continued). EA 9377 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
NPSG	ET-PP	1	0.00	0.00	0.00	0.06	0.06	0.06	100%
		2	0.16	0.16	0.16	0.19	0.19	0.19	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.04	0.04	0.04	0.04	0.04	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.03***	***0.04***	***0.04***	***0.06***	***0.06***	***0.06***	***100%***
	ET-V	1	0.08	0.08	0.08	0.08	0.08	0.08	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.04	0.04	0.04	0.04	0.04	0.04	100%
		4	0.00	0.00	0.00	0.05	0.05	0.05	100%
		5	0.00	0.07	0.07	0.07	0.07	0.07	100%
		Average	***0.02***	***0.04***	***0.04***	***0.05***	***0.05***	***0.05***	***100%***
	AT-PP	1	0.00	0.05	0.05	0.05	0.13	0.13	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.09	0.09	0.09	0.09	0.09	0.09	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.07	0.07	0.07	0.15	0.15	0.15	100%
		Average	***0.03***	***0.04***	***0.04***	***0.06***	***0.07***	***0.07***	***100%***
	AT-V	1	0.00	0.05	0.11	0.11	0.11	0.11	100%
		2	0.00	0.06	0.06	0.06	0.11	0.11	100%
		3	0.07	0.07	0.07	0.07	0.07	0.07	100%
		4	0.10	0.10	0.29	0.29	0.29	0.29	100%
		5	0.00	0.04	0.04	0.04	0.04	0.04	100%
		Average	***0.03***	***0.06***	***0.11***	***0.11***	***0.12***	***0.12***	***100%***
Scuff-sand / solvent wipe	ET-V	1	Fell apart while driving the wedges						0%
		2							0%
		3							0%
		4							0%
		5							0%
		Average							***0%***

Table B-13. Magnobond 6392-2 Lap Shear Test Results

Surface Preparation	Cure Cycle	Test Temperature	Lap Shear Strength (psi)						Failure Mode (% Coh)
			1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	75°F	5108	5151	5311	5276	4988	***5167***	100%
		160°F	4455	4415	4423	4091	3971	***4271***	100%
		180°F	3501	3256	3425	3762	3339	***3457***	100%
	ET-V	75°F	4205	4014	3790	3891	4012	***3982***	95%
		160°F	3056	3020	3168	3494	3150	***3178***	100%
		180°F	2843	2825	2825	3026	3467	***2997***	100%
	AT-PP	75°F	5067	5031	5197	4901	5117	***5063***	100%
		160°F	2898	2545	2157	2268	2590	***2492***	100%
		180°F	2275	1960	2386	2251	1901	***2155***	100%
	AT-V	75°F	4809	4274	4249	4067	3815	***4243***	100%
		160°F	2568	2656	2517	1752	2428	***2384***	100%
		180°F	2252	2026	1375	2218	2447	***2064***	100%
NPSG	ET-PP	75°F	3755	3927	3747	3798	3808	***3807***	96%
		160°F	2122	1356	1784	1252	888	***1480***	94%
		180°F	2208	1624	1886	2100	1390	***1842***	99%
	ET-V	75°F	3407	3333	3249	3347	3324	***3332***	100%
		160°F	2142	2250	1330	2106	2018	***1969***	100%
		180°F	1316	768	1454	1842	1752	***1426***	100%
	AT-PP	75°F	3778	3573	3421	3417	3831	***3604***	96%
		160°F	2167	2584	1867	1400	1402	***1884***	98%
		180°F	1212	1365	1818	1504	1161	***1412***	98%
	AT-V	75°F	3044	2444	2616	2396	2254	***2551***	98%
		160°F	2136	1868	1804	2302	2074	***2037***	93%
		180°F	2110	2112	1658	1043	941	***1573***	95%
Scuff-sand/solvent wipe	ET-V	75°F	3600	3165	2919	2869	3196	***3150***	56%
		160°F	2160	1252	1262	1340	848	***1372***	94%
		180°F	980	1330	1812	1766	1822	***1542***	99%

Table B-14. Magnobond 6392-2 Floating Roller Peel Test Results

Surface Preparation	Cure Cycle	75°F Peel Strength (pli)						Failure Mode (% Coh)
		1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	30.6	28.2	27.8	29.0	28.4	***28.8***	100%
	ET-V	25.3	24.0	23.8	25.2	24.1	***24.5***	100%
	AT-PP	36.5	36.2	35.8	36.0	34.3	***35.8***	100%
	AT-V	39.8	39.3	37.6	36.9	34.1	***37.5***	97%
NPSG	ET-PP	18.0	20.2	19.3	17.6	15.6	***18.1***	100%
	ET-V	18.9	15.8	17.2	16.7	18.5	***17.4***	100%
	AT-PP	28.0	33.7	33.3	33.3	33.0	***32.3***	100%
	AT-V	29.8	27.6	26.9	30.1	28.4	***28.6***	98%
Scuff-sand / solvent wipe	ET-V	2.9	3.1	3.0	3.0	3.1	***3.0***	0%

Table B-15. Magnobond 6392-2 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA/BR 127	ET-PP	1	0.00	0.00	0.08	0.08	0.14	0.14	100%
		2	0.00	0.00	0.00	0.00	0.07	0.07	100%
		3	0.00	0.00	0.00	0.00	0.06	0.06	100%
		4	0.00	0.00	0.00	0.08	0.08	0.08	100%
		5	0.00	0.00	0.00	0.08	0.08	0.08	100%
		Average	***0.00***	***0.00***	***0.02***	***0.05***	***0.09***	***0.09***	***100%***
	ET-V	1	0.00	0.00	0.00	0.07	0.07	0.11	100%
		2	0.00	0.00	0.00	0.00	0.00	0.00	100%
		3	0.00	0.00	0.00	0.00	0.00	0.00	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.00	0.00	100%
		Average	***0.00***	***0.00***	***0.00***	***0.01***	***0.01***	***0.02***	***100%***
	AT-PP	1	0.00	0.00	0.06	0.12	0.22	0.22	100%
		2	0.00	0.04	0.04	0.12	0.20	0.20	100%
		3	0.00	0.00	0.04	0.04	0.04	0.04	100%
		4	0.00	0.00	0.04	0.04	0.17	0.22	100%
		5	0.11	0.11	0.11	0.19	0.30	0.30	100%
		Average	***0.02***	***0.03***	***0.06***	***0.10***	***0.19***	***0.20***	***100%***
	AT-V	1	0.08	0.08	0.08	0.08	0.14	0.14	100%
		2	0.00	0.00	0.00	0.00	0.00	0.04	100%
		3	0.09	0.09	0.09	0.09	0.16	0.16	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.00	0.00	0.12	0.12	100%
		Average	***0.03***	***0.03***	***0.03***	***0.03***	***0.08***	***0.09***	***100%***

Table B-15 (continued). Magnobond 6392-2 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
NPSG	ET-PP	1	0.00	0.00	0.13	0.13	0.19	0.19	0%
		2	0.07	0.07	0.15	0.15	0.20	0.20	40%
		3	0.00	0.06	0.11	0.17	0.17	0.17	0%
		4	0.09	0.09	0.15	0.20	0.20	0.20	70%
		5	0.00	0.00	0.07	0.07	0.12	0.12	60%
		Average	***0.03***	***0.04***	***0.12***	***0.14***	***0.18***	***0.18***	***34%***
	ET-V	1	0.00	0.05	0.12	0.16	0.16	0.16	70%
		2	0.09	0.09	0.15	0.15	0.21	0.21	50%
		3	0.07	0.11	0.16	0.16	0.16	0.16	40%
		4	0.00	0.07	0.12	0.17	0.17	0.17	70%
		5	0.11	0.11	0.19	0.19	0.19	0.19	100%
		Average	***0.05***	***0.09***	***0.15***	***0.17***	***0.18***	***0.18***	***66%***
	AT-PP	1	0.16	0.24	0.54	0.67	0.67	0.67	0%
		2	0.11	0.11	0.54	0.66	0.66	0.66	0%
		3	0.26	0.41	0.77	0.90	0.90	0.96	0%
		4	0.11	0.38	0.86	0.94	0.94	1.00	0%
		5	0.14	0.36	0.73	0.80	0.80	0.87	0%
		Average	***0.16***	***0.30***	***0.69***	***0.79***	***0.79***	***0.83***	***0%***
	AT-V	1	0.00	0.00	0.00	0.07	0.07	0.07	90%
		2	0.00	0.07	0.18	0.39	0.43	0.43	0%
		3	0.00	0.00	0.00	0.00	0.00	0.05	90%
		4	0.10	0.10	0.10	0.10	0.20	0.28	0%
		5	0.05	0.05	0.05	0.21	0.31	0.35	0%
		Average	***0.03***	***0.04***	***0.07***	***0.15***	***0.20***	***0.24***	***36%***
Scuff-sand / solvent wipe	ET-V	1	0.94	0.94	1.04	1.11	1.11	1.11	0%
		2	1.18	1.18	1.24	1.24	1.24	1.24	0%
		3	1.18	1.18	1.18	1.25	1.25	1.25	0%
		4	1.16	1.16	1.16	1.21	1.21	1.21	0%
		5	0.52	0.52	0.58	0.58	0.58	0.58	0%
		Average	***1.00***	***1.00***	***1.04***	***1.08***	***1.08***	***1.08***	***0%***

Table B-16. Magnobond 6398 Lap Shear Test Results

Surface Preparation	Cure Cycle	Test Temperature	Lap Shear Strength (psi)						Failure Mode (% Coh)
			1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	75°F	5125	4794	4885	4402	4050	***4651***	98%
		160°F	4609	4063	4171	4177	4391	***4282***	100%
		180°F	3738	3795	3710	3617	3779	***3728***	100%
	ET-V	75°F	4539	4405	4639	4589	4503	***4535***	100%
		160°F	3496	3627	3694	3746	3677	***3648***	100%
		180°F	3259	3359	3159	3116	3106	***3200***	100%
	AT-PP	75°F	5204	5139	4873	5160	4755	***5026***	95%
		160°F	4079	3988	4298	4333	4407	***4221***	100%
		180°F	3852	3791	3731	3870	3757	***3800***	100%
	AT-V	75°F	4856	4575	4790	4567	4490	***4656***	100%
		160°F	2905	2629	2590	2790	2788	***2740***	100%
		180°F	2598	2552	2689	2794	2776	***2682***	100%
NPSG	ET-PP	75°F	3804	3642	3835	3853	3924	***3812***	95%
		160°F	2918	3035	3094	2812	2861	***2944***	88%
		180°F	3058	3167	2827	3057	2902	***3002***	81%
	ET-V	75°F	3290	3156	3296	3277	3389	***3282***	92%
		160°F	2702	2650	2730	2808	2898	***2758***	94%
		180°F	2482	2288	2730	2768	2530	***2560***	81%
	AT-PP	75°F	3504	3306	3286	3521	3913	***3506***	100%
		160°F	2244	2303	2230	2136	2008	***2184***	81%
		180°F	2277	2333	2388	2149	2206	***2271***	74%
	AT-V	75°F	3335	3398	3258	3369	3491	***3370***	99%
		160°F	2004	2082	1914	1863	1887	***1950***	84%
		180°F	2064	1952	1996	2158	2226	***2079***	77%
Scuff-sand/solvent wipe	ET-V	75°F	2578	2534	2618	2775	2810	***2663***	56%
		160°F	2402	2256	2472	2450	2456	***2407***	84%
		180°F	2326	2422	2394	2516	2536	***2439***	85%

Table B-17. Magnobond 6398 Floating Roller Peel Test Results

Surface Preparation	Cure Cycle	75°F Peel Strength (pli)						Failure Mode (% Coh)
		1	2	3	4	5	*Avg*	
PAA/BR 127	ET-PP	25.3	18.9	18.5	23.9	28.4	***23.0***	100%
	ET-V	21.7	24.5	23.5	24.2	27.3	***24.2***	100%
	AT-PP	34.7	37.6	39.2	37.4	32.7	***36.3***	100%
	AT-V	36.1	32.5	31.0	30.9	29.4	***32.0***	100%
NPSG	ET-PP	23.3	19.0	12.3	14.9	24.8	***18.9***	100%
	ET-V	16.8	13.5	11.0	12.6	13.0	***13.4***	100%
	AT-PP	26.7	26.7	19.4	30.8	28.1	***26.3***	82%
	AT-V	28.4	27.9	28.1	26.5	24.9	***27.2***	100%
Scuff-sand / solvent wipe	ET-V	3.3	4.8	3.9	2.8	4.2	***3.8***	0%

Table B-18. Magnobond 6398 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
PAA/BR 127	ET-PP	1	0.06	0.06	0.06	0.11	0.11	0.11	100%
		2	0.03	0.03	0.03	0.03	0.03	0.03	100%
		3	0.05	0.05	0.05	0.05	0.12	0.12	100%
		4	0.00	0.00	0.00	0.00	0.00	0.00	100%
		5	0.00	0.00	0.09	0.09	0.09	0.09	100%
		Average	***0.03***	***0.03***	***0.05***	***0.06***	***0.07***	***0.07***	***100%***
	ET-V	1	0.00	0.00	0.00	0.00	0.07	0.07	100%
		2	0.00	0.00	0.00	0.00	0.04	0.04	100%
		3	0.00	0.00	0.00	0.04	0.04	0.04	100%
		4	0.00	0.00	0.04	0.04	0.04	0.04	100%
		5	0.00	0.00	0.00	0.00	0.00	0.07	100%
		Average	***0.00***	***0.00***	***0.01***	***0.02***	***0.04***	***0.05***	***100%***
	AT-PP	1	0.00	0.00	0.09	0.09	0.09	0.16	100%
		2	0.00	0.00	0.09	0.09	0.09	0.09	100%
		3	0.00	0.00	0.12	0.12	0.12	0.12	100%
		4	0.00	0.00	0.12	0.12	0.12	0.12	100%
		5	0.05	0.05	0.12	0.12	0.12	0.12	100%
		Average	***0.01***	***0.01***	***0.11***	***0.11***	***0.11***	***0.12***	***100%***
	AT-V	1	0.06	0.06	0.06	0.14	0.14	0.14	100%
		2	0.05	0.05	0.05	0.05	0.05	0.05	100%
		3	0.06	0.06	0.06	0.16	0.16	0.16	100%
		4	0.06	0.06	0.06	0.13	0.13	0.13	100%
		5	0.09	0.09	0.09	0.16	0.16	0.16	100%
		Average	***0.06***	***0.06***	***0.06***	***0.13***	***0.13***	***0.13***	***100%***

Table B-18 (continued). Magnobond 6398 Follow-On Wedge Test Results

Surface Preparation	Cure Cycle	Specimen Number	Cummulative Crack Growth, in						Failure Mode, % coh.
			4 Hrs	24 Hrs	7 Days	14 Days	21 Days	28 Days	
NPSG	ET-PP	1	0.00	0.00	0.11	0.11	0.11	0.17	95%
		2	0.00	0.06	0.13	0.13	0.13	0.13	100%
		3	0.00	0.00	0.07	0.07	0.07	0.12	100%
		4	0.08	0.16	0.16	0.16	0.16	0.16	95%
		5	0.04	0.04	0.04	0.04	0.13	0.13	100%
		Average	***0.02***	***0.05***	***0.10***	***0.10***	***0.12***	***0.14***	***98%***
	ET-V	1	0.08	0.08	0.08	0.18	0.18	0.18	100%
		2	0.00	0.00	0.09	0.09	0.09	0.09	100%
		3	0.00	0.00	0.14	0.14	0.14	0.14	100%
		4	0.00	0.00	0.07	0.16	0.16	0.16	100%
		5	0.00	0.00	0.07	0.14	0.14	0.14	100%
		Average	***0.02***	***0.02***	***0.09***	***0.14***	***0.14***	***0.14***	***100%***
	AT-PP	1	0.00	0.13	0.13	0.13	0.17	0.17	95%
		2	0.00	0.09	0.17	0.17	0.17	0.17	100%
		3	0.08	0.08	0.28	0.28	0.33	0.33	95%
		4	0.14	0.23	0.23	0.31	0.31	0.31	95%
		5	0.09	0.09	0.15	0.15	0.15	0.22	95%
		Average	***0.06***	***0.12***	***0.19***	***0.21***	***0.23***	***0.24***	***96%***
	AT-V	1	0.00	0.07	0.23	0.23	0.23	0.23	95%
		2	0.00	0.00	0.00	0.12	0.12	0.12	95%
		3	0.00	0.06	0.17	0.17	0.21	0.21	80%
		4	0.00	0.00	0.20	0.20	0.20	0.20	100%
		5	0.00	0.00	0.14	0.14	0.14	0.14	95%
		Average	***0.00***	***0.03***	***0.15***	***0.17***	***0.18***	***0.18***	***93%***
Scuff-sand / solvent wipe	ET-V	1	0.51	0.51	0.51	0.51	0.51	0.58	0%
		2	0.44	0.44	0.50	0.50	0.50	0.50	0%
		3	0.78	0.78	0.85	0.85	0.85	0.85	0%
		4	0.91	0.91	0.91	1.01	1.01	1.01	0%
		5	0.77	0.77	0.77	0.85	0.85	0.85	0%
		Average	***0.68***	***0.68***	***0.71***	***0.74***	***0.74***	***0.76***	***0%***

List of Acronyms, Abbreviations, and Symbols

ACRONYM, ABREVIATION, SYMBOL	DESCRIPTION
AFRL	Air Force Research Laboratory
ASTM	ASTM International
AT	Ambient temperature
Avg	Average
Coh	Cohesive
°	Degree
EN	Engineering Directorate
ET	Elevated temperature
F	Fahrenheit
g	Gram
Hg	Mercury
in	Inch
n/a	Not available
NPSG	Nylon pad/sol-gel
%	Percent
PAA	Phosphoric acid anodize
PP	Positive pressure
psi	Pounds per square inch
RH	Relative humidity
RXSA	Materials Integrity Branch
UDRI	University of Dayton Research Institute
V	Vacuum
VFN	Very fine
WR-ALC	Warner Robins Air Logistics Complex